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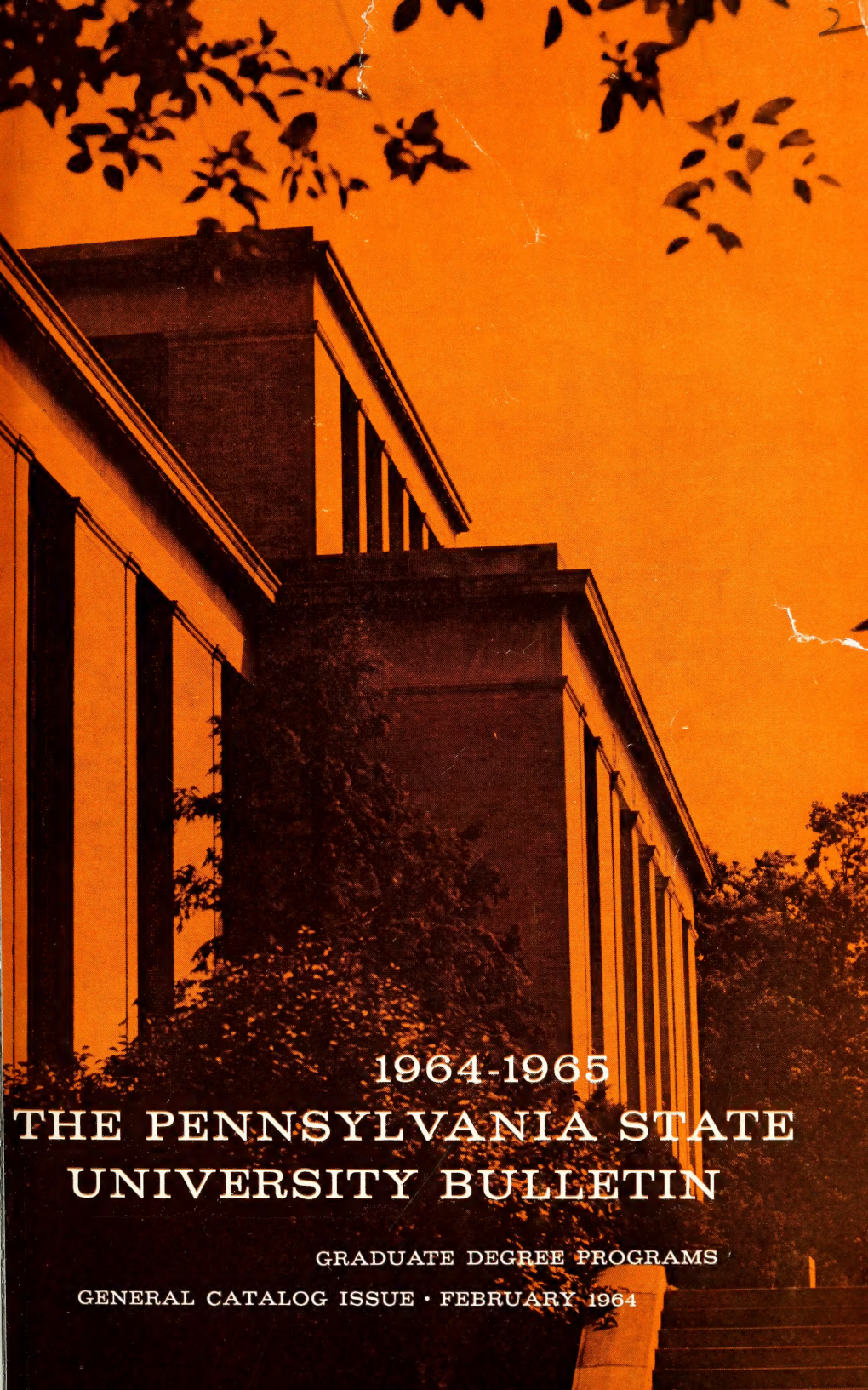
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1964-1965
THE PENNSYLVANIA STATE UNIVERSITY BULLETIN

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE · FEBRUARY 1964

OFFICE OF THE GRADUATE SCHOOL

101 Willard Building
University Park, Pa., 16802

Telephone: Area Code 814, 865-6323

NOTICE: The University operates throughout the year on a four-term basis. The fall, winter, spring, and summer terms consist of 10 weeks each.

LOCATION: The post office address of The Pennsylvania State University is University Park, Pennsylvania, but the town in which the University is located is State College.

THE PENNSYLVANIA STATE UNIVERSITY BULLETIN

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UNIVERSITY PARK, PA., 16802

1964-1965

THE PENNSYLVANIA STATE UNIVERSITY

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*GRADUATE CALENDAR

WINTER TERM 1964

229

NOVEMBER 1963

7 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1964
7 Thursday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1964

JANUARY 1964

7-8 Tuesday and Wednesday—Winter Term Registration
7-8 Tuesday and Wednesday—Oral Examination in Foreign Languages for Advanced Degree Candidates
9 Thursday—Winter Term Classes Begin 8 a.m.
9 Thursday—Last Date for Registering with Foreign Language Departments for Written Language Examination
18 Saturday—Last Date for Adding Courses to Approved Schedules
21 Tuesday—Graduate Faculty Meeting
27 Monday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in March

FEBRUARY

3 Monday—Written Foreign Language Examination for Advanced Degree Candidates
18 Tuesday—Graduate Faculty Meeting
22 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee
29 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
29 Saturday—Last Date for a March Graduate to Deliver Master's Thesis to Adviser
29 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally

MARCH

7 Saturday—Theses Due in Graduate School Office 12 Noon
7 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in March
18 Wednesday—Winter Term Classes End 9:55 p.m.
19-21 Thursday to Saturday—Final Examinations
22 Sunday—Commencement

SPRING TERM 1964

JANUARY 1964

31 Friday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1964
31 Friday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1964

*This calendar was approved June 10, 1963. It is subject to change without notice.

MARCH

31 Tuesday—Spring Term Registration
31 Tuesday—Oral Examination in Foreign Languages for Advanced Degre Candidates

APRIL

1 Wednesday—Spring Term Registration
1 Wednesday—Oral Examination in Foreign Languages for Advanced De gree Candidates
2 Thursday—Spring Term Classes Begin 8 a.m.
2 Thursday—Last Date for Registering with Foreign Language Department for Written Language Examinations
11 Saturday—Last Date for Adding Courses to Approved Schedules
20 Monday—Last Date for Paying Thesis Fees and for Informing Recorde of Intention to Graduate in June
21 Tuesday—Graduate Faculty Meeting
27 Monday—Written Foreign Language Examination for Advanced Degre Candidates

MAY

16 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis t Committee
19 Tuesday—Graduate Faculty Meeting
23 Saturday—Last Date for Final Oral Doctoral Examination for Jun Graduates
23 Saturday—Last Date for a June Graduate to Deliver Master's Thesis t Adviser
23 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hoo Locally
30 Saturday—Theses Due in Graduate School Office 12 Noon
30 Saturday—Last Date for Submitting a Petition to Graduate in Absenti in June

JUNE

10 Wednesday—Spring Term Classes End 9:55 p.m.
11-13 Thursday to Saturday—Final Examinations
14 Sunday—Commencement

SUMMER TERM 1964

APRIL 1964

20 Monday—Last Date for a Prospective Graduate Student to Apply for A mission to the Summer Term 1964
20 Monday—Last Date for a Graduate Student to Apply for Permission Resume Study in the Summer Term 1964

JUNE

19 Friday—Summer Term Registration
19 Friday—Oral Examination in Foreign Languages for Advanced Degr Candidates
22 Monday—Summer Term Classes Begin 8 a.m.
22 Monday—Last Date for Registering with Foreign Language Departmer for Written Language Examinations

ULY

1 Wednesday—Last Date for Adding Courses to Approved Schedules
*4 Saturday—Independence Day
6 Monday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in September
13 Monday—Written Foreign Language Examinations for Advanced Degree Candidates
21 Tuesday—Graduate Faculty Meeting

UGUST

10 Monday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee
17 Monday—Last Date for Final Oral Doctoral Examination for September Graduates
17 Monday—Last Date for a September Graduate to Deliver Master's Thesis to Adviser
17 Monday—Last Date for a September Graduate to Rent Cap, Gown, and Hood Locally
18 Tuesday—Graduate Faculty Meeting
24 Monday—Theses Due in Graduate School Office 12 Noon
24 Monday—Last Date for Submitting a Petition to Graduate in Absentia in September
31 Monday—Summer Term Classes End 9:55 p.m.

EPTEMBER

1-3 Tuesday to Thursday—Final Examinations
7 Monday—Commencement

FALL TERM 1964

ULY 1964

23 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Fall Term 1964
23 Thursday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1964

EPTEMBER

23-26 Wednesday to Saturday Noon—Fall Term Registration
23-26 Wednesday to Saturday Noon—Oral Examination in Foreign Languages for Advanced Degree Candidates
28 Monday—Fall Term Classes Begin 8 a.m.
28 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

CTOBER

7 Wednesday—Last Date for Adding Courses to Approved Schedules
12 Monday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in December
19 Monday—Written Foreign Language Examinations for Advanced Degree Candidates
20 Tuesday—Graduate Faculty Meeting

*Classes which would have met on Saturday, July 4, will meet according to schedule on Monday, igust 31, 1964.

NOVEMBER

14 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee
17 Tuesday—Graduate Faculty Meeting
21 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates
21 Saturday—Last Date for a December Graduate to Deliver Master's Thesis to Adviser
21 Saturday—Last Date for a December Graduate to Rent Cap, Gown, and Hood Locally
†26 Thursday—Thanksgiving Day
28 Saturday—Theses Due in Graduate School Office 12 Noon
28 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in December

DECEMBER

7 Monday—Fall Term Classes End 9:55 p.m.
8-10 Tuesday to Thursday—Final Examinations
12 Saturday—Commencement

WINTER TERM 1965

NOVEMBER 1964

5 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1965
5 Thursday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1965

JANUARY 1965

5-6 Tuesday and Wednesday—Winter Term Registration
5-6 Tuesday and Wednesday—Oral Examination in Foreign Languages for Advanced Degree Candidates
7 Thursday—Winter Term Classes Begin 8 a.m.
7 Thursday—Last Date for Registering with Foreign Language Department for Written Language Examinations
16 Saturday—Last Date for Adding Courses to Approved Schedules
19 Tuesday—Graduate Faculty Meeting
25 Monday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in March

FEBRUARY

1 Monday—Written Foreign Language Examinations for Advanced Degree Candidates
16 Tuesday—Graduate Faculty Meeting
20 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee
27 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
27 Saturday—Last Date for a March Graduate to Deliver Master's Thesis to Adviser
27 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally

†Classes which would have met on Thursday, November 26, will meet according to schedule on Monday, December 7, 1964.

MARCH

6 Saturday—Theses Due in Graduate School Office 12 Noon
6 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in March
17 Wednesday—Winter Term Classes End 9:55 p.m.
18-20 Thursday to Saturday—Final Examinations
21 Sunday Afternoon—Commencement

SPRING TERM 1965

JANUARY 1965

26 Tuesday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1965
26 Tuesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1965

MARCH

26-27 Friday and Saturday—Spring Term Registration
26-27 Friday and Saturday—Oral Examination in Foreign Languages for Advanced Degree Candidates
29 Monday—Spring Term Classes Begin 8 a.m.
29 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

APRIL

7 Wednesday—Last Date for Adding Courses to Approved Schedules
12 Monday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in June
19 Monday—Written Foreign Language Examinations for Advanced Degree Candidates
20 Tuesday—Graduate Faculty Meeting

MAY

15 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
18 Tuesday—Graduate Faculty Meeting
22 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
22 Saturday—Last Date for a June Graduate to Deliver Master's Thesis to Adviser
22 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally
29 Saturday—Theses Due in Graduate School Office 12 Noon
29 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in June

JUNE

5 Saturday—Spring Term Classes End 12:25 p.m.
7-9 Monday to Wednesday—Final Examinations
12 Saturday—Commencement

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George W. Brindley, Ph.D. (Leeds)	*Professor of Solid State Technology*
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Francis T. Hall, Jr., M.S. (M.I.T.), P.E.	*Professor of Electrical Engineering*
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Carroll E. Heist, Ph.D. (Illinois)	*Associate Professor of Microbiology*
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Dorothy Houghton, Ph.D. (Columbia)	*Professor of Home Economics*
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Paul M. Kendig, Ph.D. (Penn State)	*Professor of Engineering Research*
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Philip S. Klein, Ph.D. (Pennsylvania)	*Professor of American History*

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Russell E. Larson, Ph.D. (Minnesota)	*Professor of Horticulture*
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Laurence H. Lattman, Ph.D. (Cincinnati)	*Assoc. Prof. of Geomorphology*
Peter M. Lavin, Ph.D. (Penn State)	*Assistant Professor of Geophysics*
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Laurent LeSage, Ph.D. (Illinois)	*Professor of Romance Languages*
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Peirce F. Lewis, Ph.D. (Michigan)	*Professor of Geography*
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Eva M. Lüders, Ph.D. (Goettingen)	*Assoc. Prof. of German and Comp. Lit.*
Ernest H. Ludwig, Ph.D. (Pennsylvania)	*Professor of Microbiology*
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Arthur M. Wellington, M.A. (Ohio State)	*Prof. of Counselor Education*
Clifford C. Wernham, Ph.D. (Cornell)	*Professor of Plant Pathology*
Frederick L. Wernstedt, Ph.D. (U.C.L.A.)	*Associate Professor of Geography*
David L. Westby, Ph.D. (Michigan State)	*Assistant Professor of Sociology*
Woldemar Weyl, Dr.Ing. (Aachen)	*Evan Pugh Res. Prof. of Phys. Sci.*
Francis L. Whaley, Ph.D. (Michigan)	*Associate Professor of Psychology*
Ralph H. Wherry, M.A. (Penn State), C.L.U.	*Professor of Insurance*
Benjamin A. Whisler, Sc.D. (Harvard), P.E.	*Professor of Civil Engineering*
Eugene E. White, Ph.D. (Louisiana State)	*Associate Professor of Speech*
Wallace E. White, Ph.D. (Yale)	*Professor of Wood Technology*
Duane H. Whittier, Ph.D. (Illinois)	*Instructor in Philosophy*
Delpha E. Wiesendanger, M.S. (Cornell)	*Prof. of Home Mgmt. and Housing*
Thomas A. Wiggins, Ph.D. (Penn State)	*Professor of Physics*
Mary L. Willard, Ph.D. (Cornell)	*Professor of Chemistry*
Arthur L. Williams, Ph.D. (Pennsylvania), C.L.U.	*Assoc. Prof. of Insurance*
Eugene G. Williams, Ph.D. (Penn State)	*Associate Professor of Geology*
William A. Williams, Ed.D. (Pittsburgh)	*Professor of Industrial Education*
Merritt A. Williamson, Ph.D. (Yale), P.E.	*Professor of Engineering*
William O. Williamson, Ph.D., D.Sc. (London)	*Assoc. Prof. of Cer. Tech.*
Donald J. Willower, Ed.D. (Buffalo)	*Associate Professor of Education*
Rolf C. Winter, D.Sc. (Carnegie Tech.)	*Associate Professor of Physics*
George F. Wislicenus, Ph.D. (California Tech.), P.E.	*Prof. of Aero. Eng.*
Francis A. Wood, Ph.D. (Minnesota)	*Asst. Professor of Forest Pathology*
Merrill Wood, M.S. (Penn State)	*Assoc. Professor of Zoology*
Arthur E. Woodward, Ph.D. (Brooklyn Polytech.)	*Assoc. Professor of Physics*
Richard N. Work, Ph.D. (Cornell)	*Assoc. Professor of Physics*
Harold D. Wright, Ph.D. (Columbia)	*Assoc. Professor of Mineralogy*
James E. Wright, Jr., Ph.D. (Cornell)	*Professor of Genetics*
Lauren A. Wright, Ph.D. (California Tech.)	*Professor of Geology*
Peter J. Wyllie, Ph.D. (St. Andrews)	*Associate Professor of Petrology*
Jack Yahia, Ph.D. (Northwestern)	*Assistant Professor of Physics*
Kelly Yeaton, M.A. (Washington)	*Assoc. Professor of Theatre Arts*
Philip Young, Ph.D. (Iowa)	*Professor of American Literature*
Joseph Zafforoni, Ed.D. (Columbia)	*Associate Professor of Education*
Martin L. Zeigler, Ph.D. (Penn State)	*Research Assoc. in Psychology*
Wilbur Zelinsky, Ph.D. (California)	*Professor of Geography*
Harold P. Zelko, M.A. (Ohio State), LL.B.	*Professor of Speech*
Leonard N. Zimmerman, Ph.D. (Cornell)	*Professor of Bacteriology*
Harry D. Zook, Ph.D. (Penn State)	*Professor of Chemistry*
George S. Zoretich, M.A. (Penn State)	*Professor of Art*

LECTURERS

Arnold Addison, M.A. (West Virginia)	*Assoc. Prof. of Eng. Research*
Charles D. Auvenshine, M.Ed. (Missouri)	*Instructor in Education*
Leland L. Beik, Ph.D. (Columbia)	*Associate Professor of Marketing*
Clarence O. Bergeson, Ed.D. (Columbia)	*Associate Professor of Education*
Ward D. Bouwsma, Ph.D. (Michigan)	*Assistant Professor of Mathematics*
William S. Decker, M.A. (Iowa)	*Assistant Professor of Marketing*

Aaron Druckman, B.A. (Penn State)	*Associate Professor of Philosophy*
Alfred J. Engel, Ph.D. (Wisconsin)	*Asst. Prof. of Chemical Engineering*
M. Geraldine Gage, Ph.D. (Cornell)	*Assistant Professor of Family Economics*
Barton L. Jenks, Jr., M.S. (Princeton)	*Assoc. Prof. of Mechanical Engineering*
Oscar A. Kimmel, M.S. (Penn State)	*Assistant Professor of Farm Mechanics*
J. Campbell Lester, M.S. (Penn State), P.E.	*Assoc. Prof. of Mechanical Eng.*
Ronald W. Linker, Ph.D. (Johns Hopkins)	*Assistant Professor of History*
Robert L. Masson, Ed.D. (Buffalo)	*Assistant Professor of Education*
Robert A. Moore, Ph.D. (Indiana)	*Assistant Professor of Mathematics*
Nell A. Murphy, D.Ed. (Stanford)	*Associate Professor of Education*
John M. Shemick, M.A. (Michigan State)	*Assoc. Prof. of Industrial Arts Ed.*
Arthur T. Thompson, S.M. (Harvard)	*Professor of Engineering*
William J. Tisdall, Ph.D. (Illinois)	*Assistant Professor of Education*
Walter F. Westerfeld, M.S. (Penn State)	*Assistant Professor of Botany*
John R. Zimmerman, M.S. (Lehigh)	*Asst. Prof. of Mechanical Engineering*

GENERAL INFORMATION

GRADUATE WORK at The Pennsylvania State University was first offered in 1862 when two graduate students were in residence. It was given more formal recognition in 1864 by the establishment of a "course for Graduates" designed for students who, after receiving the degree of Bachelor of Scientific Agriculture, wished to do advanced work leading to the degree of Master of Scientific Agriculture. For some time there were few graduate students, and graduate instruction was relatively unorganized. Later a committee of the University Senate was given the responsibility of establishing standards and regulations governing graduate work and the granting of advanced degrees. The Graduate School was organized in 1922. Until this time only masters' degrees and certain technical degrees had been conferred. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. Still later other degrees were approved.

The faculty of the Graduate School consists of the President and certain other general administrative officers of the University, the Deans, the Librarian, the heads of departments, and those members of the instructional staff who have been authorized by the proper agencies of the Graduate School to offer graduate courses and supervise research leading to theses. It controls all academic matters pertaining to the Graduate School, subject to review by the University Senate.

The Graduate Faculty has approximately 750 members. Graduate student enrollment was about 2,500 per term for the four terms of 1962-63. The number of advanced degrees conferred in 1962-63 was 979, of which 202 were doctorates.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at Penn State by scheduling relevant courses and research at University Park. Similarly a graduate student with an appropriate major at Penn State may earn credits at Jefferson which, upon advance approval by his major department, will be accepted in partial fulfillment of degree requirements at Penn State.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in this publication, the *Manual for Graduate Students*, and the *Thesis Information Bulletin*, and for meeting the standards and requirements expressed by these regulations. The *Manual*, which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Dean's office soon after admission.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not simply an extension of undergraduate work. It operates at a definitely higher level, demands scholarship of a high order, and emphasizes research and creativity. It involves a minimum of formal requirements and regulations, and a maximum of student initiative and responsibility.

A student does not become a graduate student merely by enrolling for advanced courses after having received a baccalaureate degree. Formal admission to the Graduate School is required.

Admission is granted by the Dean of the Graduate School after approval of the application by the department in which the student plans to do his major work. Blanks to be used in making formal application for admission can be obtained from the Graduate School office. In general, a student may begin his graduate work in fall, winter, spring, or summer. Prospective students may write directly to the head of any department concerning graduate work in that specific field.

Students from other countries are encouraged to write to the Director of International Student Affairs for information concerning finances, housing, and other nonacademic matters.

CREDENTIALS—An applicant for admission should provide complete credentials, in duplicate, sent directly from other institutions to the Dean of the Graduate School at least two months prior to the opening of the term in which he plans to begin his graduate program. If the applicant has attended more than one institution, two official transcripts of the work covered at each institution are required. This applies to the complete academic record, both undergraduate and graduate.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements for an advanced degree.

UNQUALIFIED ADMISSION—For unqualified admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must have maintained during his junior and senior years a minimum grade point average equivalent to 2.5 on The Pennsylvania State University grading scale (approximately half B and half C). Finally, he must ordinarily have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of required work depending upon the field of advanced study which the student proposes to enter. The minimum grade point average of 2.5 during the last two undergraduate years is a general requirement of the Graduate School. Individual departments may require a higher average for admission in their fields.

The above requirements apply particularly to the student who has recently completed an undergraduate program and is about to begin graduate study. An applicant who has done a year or more of graduate work in a recognized graduate school will be evaluated largely on the basis of the graduate record but with some attention to undergraduate achievement. For a mature person, recognized attainment in a professional field will be considered, and reduced weight will be given to old undergraduate records.

CONDITIONAL ADMISSION—Some departments are participating in an experiment on conditional admission for applicants whose undergraduate grade point average is below 2.5 but whose qualifications in other respects seem to suggest probable success in the Graduate School. Such an applicant must realize that the initiative rests entirely with him in communicating with the department of his chosen major and that, if admitted conditionally, he does graduate work at his own risk. There is no assurance that he will subsequently be granted unqualified admission or that the credits earned will be applicable toward degree requirements. Applicants for admission on a conditional basis must have all of the essential materials for consideration for admission to that status on file with the Dean of the Graduate School at least two months before they wish to register in the Graduate School.

PROVISIONAL ADMISSION—Provisional admission may be granted to an applicant whose complete credentials are not available at the time of registration, but this admission will be subject to cancellation if the credentials, on their arrival, do not meet the requirements for admission to the Graduate School. Also, while the applicant is holding provisional admission, certification of any earned credits will be

withheld until receipt of his official credentials makes possible his unqualified admission to the Graduate School. If the provisional admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School and as a consequence will be required to cease attending any 500-level courses for which he may have registered. He may continue to attend 400-level courses provided he applies for and is accepted for registration as a special student.

ADVISERS—To assist the student in planning his program, the head of his major department will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to make an appointment for an initial language proficiency interview at the Language Testing Center for International Students, 218 Sparks Building. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. Remedial work will be prescribed as indicated by the tests.

GUESTS OF THE UNIVERSITY—The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctors' degrees who may be visiting the University for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses, and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade point average of 3). Any senior with a 3.5 grade point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400 and 500 series courses toward an advanced degree at Penn State. Upon admission to the Graduate School such credits as are relevant to the graduate field of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major and minor departments. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

STUDENT CONDUCT

The University expects that students will conduct themselves in accordance with the standards normally followed by educated men and women and in accordance with the laws of the Nation, State, and Borough. The right is reserved to sever at any time the University connection of any student whose influence is found to be injurious to the standard of morals and scholarship of the student body, or whose conduct is prejudicial to the good name of the University.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

CLASSIFICATION

At the time of admission to the University students are classified as regular graduate, general graduate, special, or undergraduate students depending upon their objectives and qualifications.

A change in classification for a graduate student is arranged through the Graduate School office and, in the case of a change from general to regular status, the approval of the head of the major department in which the student proposes to work is required.

A person holding a baccalaureate degree and working only for permanent certification as a teacher or administrator in the public schools is advised to apply for admission as a general graduate student.

REGULAR GRADUATE STUDENTS—Persons who plan to become candidates for advanced degrees at The Pennsylvania State University and have been formally admitted for advanced study in a particular field are designated as regular graduate students. The program of study is developed under the guidance of an adviser appointed by the head of the student's major department.

It should be emphasized that a student is not a "regular graduate student" unless he has been officially admitted to that status. Regular attendance in the Graduate School, or personal plans for future degree candidacy, do not in themselves carry with them the status or privileges of a regular graduate student.

A regular graduate student who has passed a candidacy evaluation is classified as a doctoral candidate.

GENERAL GRADUATE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a general graduate student. This classification includes those who plan to transfer credits to another institution and those who plan a special program of study not leading to an advanced degree.

The adviser for a general graduate student is appointed by the department head most closely associated with the student's field of interest. The student's status and standing will be reviewed by the Dean of the Graduate School at each registration. He may remain a general graduate student longer than one term only with the permission of the Dean, and for definite and good reasons.

When a general graduate student wishes to become a regular graduate student—i.e., to work for an advanced degree at this institution—he should make application to the Dean of the Graduate School for change of status. His academic record will then be evaluated to determine whether or not he is prepared to undertake graduate work for a degree in the major field of his choice. He should understand that he may thereafter apply toward degree requirements only those credits earned as a general graduate student which fit definitely and logically into an integrated degree program. There is no upper limit to the number of credits that may be so applied; neither is there a guarantee that any such credits may be applicable.

SPECIAL STUDENTS—A special student is not a graduate student, inasmuch as he has not been admitted to the Graduate School, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. A special student may register for 400-level courses, provided he has attained at least junior standing in college.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until he has met the minimum requirements for his degree, he must register for each term in which he proposes to do either course work or research, or other work on his thesis, either on or off campus. In the case of research the number of credits shall be determined by the amount of time required for the investigation, one credit representing one week of full-time graduate work.

CONTINUITY OF REGISTRATION—Any student who has interrupted the normal sequence of his graduate program is required to apply to the Dean of the Graduate School for permission to resume graduate study. It is recognized that certain students typically will not attend the summer terms whereas others will concentrate their work in these terms. Both groups, as well as certain variants, meet the spirit of the policy.

In order to register for a given term, a student who has been previously enrolled will need to apply unless he has been registered for work at University Park, for thesis research in absentia (610), or for other Penn State work off campus during certain specific terms as follows:

Summer Term—Application required unless the student was registered for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered for the preceding fall term.

Spring Term—Application required unless the student was registered for the preceding winter term.

PROCEDURE—For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs, which is submitted to the Dean of the Graduate School for his approval. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done off the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed by the same deadline as applies on the campus.

A student must register for courses audited as well as for those taken for credit.

EXCEPTIONS—When a candidate has met minimum requirements for a degree, further registration shall be required only for course work, project work, and research work requiring the use of University facilities and supplies (including laboratory, library, and others). This means, for instance, that a student who has earned 90 credits in a doctoral program and has met all requirements for the degree except for the completion of his thesis and the passing of the final oral examination need not register for the additional research which may be required, whether it be done at University Park or elsewhere, provided he does not use University facilities or supplies. On the other hand, a student who uses University facilities or supplies for his research must be registered for credit at all times, regardless of the number of credits that may accrue before he completes his work.

A candidate need not register for the term at the end of which the degree is to be conferred solely for the purpose of graduating. He will, of course, be required to register if he has a significant amount of work to complete unless relieved of this obligation by the previous paragraph. He will not be required to register if he has only minor revisions of his thesis to complete and/or the final oral examination to pass.

TIME OF REGISTRATION—Registration days for all students are indicated in the University Calendar.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructors to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the amount of time which he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

LOADS, ACADEMIC AND EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule in planning his academic program.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their Graduate School experience to a maximum extent. Therefore the Graduate School reserves the right to deny admission or registration to part-time students who (a) propose schedules of few credits which seem to reflect little real interest in graduate work or would not seem to require serious effort, or (b) wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality in their graduate work.

"Doing graduate work" means more than doing what is required in courses or in research. It means living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Overloads make it difficult and often impossible to do graduate work so conceived. Hence the following "protective" schedule of permitted loads for employed students has been adopted:

EMPLOYMENT	ACADEMIC LOAD
0 hours per week	8-10 credits allowed
10 hours per week	7- 9 credits allowed
20 hours per week	5- 7 credits allowed
30 hours per week	4- 5 credits allowed
40 hours per week	1- 4 credits allowed

This means, for example, that anyone working 20 hours per week (about half-time) whether as a half-time graduate assistant, as an employee on campus, or as an employee off-campus, will be limited in the amount of graduate work for which he may register to about three fifths of a normal full-time load (i.e., to 5-7 credits). The word employment is used in a very general sense and includes working for indirect compensation, such as housekeeping, working in the family business, maintaining a large vegetable garden, etc. Hence, all students who are thus employed will be expected to adjust their academic loads accordingly. Exceptions, in the case of students who have demonstrated unusual ability, must be arranged with the Dean of the Graduate School at the time of registration. (See also Visiting and Auditing Classes.)

A student holding a fellowship, graduate assistantship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no grade and cannot subsequently secure credit for work done in the course.

Ordinarily a student is not permitted to count courses for which he is registered as an auditor as a part of the minimum for which he is required to register by virtue of his status. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for the course as an auditor.

In the 1G and 2G courses offered by the language departments, visiting is not permitted and no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the language, he will be required to count the course as a part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

STATUS UNDER SELECTIVE SERVICE—As soon as an applicant has been admitted to the Graduate School, his local board will be informed *provided* the applicant requests it and has given the necessary information. As soon as he receives notification of admission, the applicant should check with the Associate Registrar to see that everything is in order.

A student is certified to be a full-time student insofar as Selective Service is concerned if he schedules at least 8 credits in a term, or if he holds an appointment as a quarter-time or half-time graduate assistant, or if he is serving an internship or holding a traineeship under approved conditions.

Whenever a student changes his status so as no longer to be considered a full-time student, fails to make satisfactory progress, or makes a drastic change in his declared goal, his local board will be notified.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

For graduate courses (500 series) and for research or thesis (600 or 610) one of three grades may be given:

H for Honors, indicating definitely superior attainment.
P for Pass, indicating acceptable but not superior attainment.
F for Fail, indicating failure to attain the acceptable minimum standard of work or to spend an adequate amount of time doing the work scheduled.

In addition to the quality grades listed above, two symbols, "deferred" and R, may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "deferred" in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, the instructor may report the symbol R in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication

of its quality. An R remains on the student's transcript permanently. If, after having submitted a series of R symbols, the instructor reports a grade of H, P, or F for a specific term, this grade is considered to apply to the preceding series of registrations and to denote the quality of that entire series.

For 400 series courses one of five grades may be given:

Grade	*Percentage Equivalent*	*Grade Point Equivalent*
A	90-100	4
B	80- 89	3
C	70- 79	2
D	60- 69	1
F (Failure)	0- 59	0

Grades below B do not carry graduate credit and are considered failures in the program of a graduate student.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate, and to pay thesis fees at the beginning of the term in which he expects to receive an advanced degree. Deadlines are given in the calendar.

Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School for sufficient reasons. See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation.

All degrees conferred are tentative until final grade reports have been received even though the student's name may have appeared in the commencement program.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

Residents of Pennsylvania, $22 per credit with a maximum of $175 per term.

Nonresidents of Pennsylvania, on-campus work, $44 per credit with a maximum of $350 per term.

Nonresidents of Pennsylvania, research in absentia, $22 per credit with a maximum of $175 per term.

Total charge for a Vocational Education program, not exceeding 7 credits (vocational education courses are indicated by "v" following the course number), $22.

Tuition is the same for courses whether taken as an auditor or for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than 10 days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Dean of Admissions for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile of the one admitted (or of his parents, if he is a minor) within the Commonwealth for a period of at least 12 months immedi-

ately preceding the date of such petition for reclassification; and, in addition, such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following the twelfth month after such change has taken place.

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor not later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIAL CHARGES (payable as occasion demands and applicable to all students):

Admission to the Graduate School	$10.00
Privilege of late registration	10.00
Privilege of late payment	25.00
Change of schedule, each change	2.00
Thesis binding fee for master's candidate	9.00
Thesis microfilming and binding fee for doctoral candidate	44.00
Official transcript of record (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

A graduate student planning to operate a motor vehicle in the State College area should secure a copy of the leaflet *Parking and Traffic Regulations* from the Traffic Violations Officer, Room 203D, Hetzel Union Building.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fireproof, one-story, steel framework buildings. Forty-six one-bedroom units rent for $75 per month and 32 two-bedroom units rent for $85. The rent includes utilities except for electricity. Water is heated elec-

trically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle, opened in 1960, has 144 one-bedroom and 72 two-bedroom apartments in 16 two-story buildings of brick and frame construction. The units rent for $82.50 and $92.50 per month, including all utilities. The kitchens have double stainless steel sinks with disposal unit, a gas stove, kitchen cabinets, electric refrigerator, and a built-in chest of drawers in the bedroom; otherwise the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children. An application form for a Married Student Apartment may be obtained by writing to the Department of Housing and Food Services, 23 Pollock Dining Hall, University Park, Pa., 16802. Telephone: Area Code 814, 865-7501.

A married student may also find accommodations in off-campus apartments, trailers, or rooms in private homes.

Irvin Hall and Grange Hall, both located on central campus, provide for single students, both men and women. For detailed information write to Department of Housing and Food Services, 23 Pollock Dining Hall, University Park, Pa., 16802. Telephone: Area Code 814, 865-7501. Other living accommodations are available, including rooms in private homes and lodging houses. The cost varies considerably depending upon the type of accommodation. The prospective student should make arrangements well in advance of the beginning of classes because it may be very difficult to find a convenient location at the last minute. Boarding houses, restaurants, and the Hetzel Union Cafeteria on the campus are available for meals.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

ASSISTANTSHIPS

Approximately 1,000 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some departments. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department for information and application forms. Appointments are made upon the recommendation of the department head, subject to admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship requires a continuing demonstration of good scholarship.

The assistantships vary as follows:

QUARTER-TIME—The student may schedule 7-9 credits, receives a stipend in the range $219-$375 plus a grant-in-aid which covers tuition, will be required to give about 10 hours of service per week for 12 weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

HALF-TIME—The student may schedule 5-7 credits, receives a stipend in the range $438-$750 plus a grant-in-aid which covers tuition, will be required to give about 20 hours of service per week for 12 weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

THREE-QUARTER-TIME—The student may schedule 4-5 credits, receives a stipend in the range $657-$1,125 plus a grant-in-aid which covers tuition, will be required to give about 30 hours of service per week for 12 weeks, and will be considered a part-time student.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for a grant-in-aid to cover tuition for the succeeding term without service, if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must apply to the head of the department in which he has held the assistantship.

A graduate assistant may not accept additional employment, either at the University or elsewhere, during the period for which service to the University is required under the appointment.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS

More than 150 fellowships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows carry a full-time graduate program, receive a stipend which varies with the award, and receive a grant-in-aid paid by the donor of the fellowship to provide for all tuition. They may not accept employment during the term of their appointment, nor are they required to render any service to the University. In some cases a fellow will be expected to limit his research to a broad field specified by the donor. Fellows are required to pay specific charges, such as admission, late registration, change of schedule, thesis binding, microfilming, and parking fees.

GRADUATE SCHOOL FELLOWSHIPS—Eleven fellowships, each paying a stipend of $2,000 for the fall, winter, and spring terms, and providing a grant-in-aid to cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding advanced graduate students in any field, although preference is given to applicants majoring in the humanities and social sciences. An applicant must have completed at least one full year of graduate study prior to beginning the fellowship tenure and be a candidate for the doctoral degree.

Applications should be addressed to the Dean of the Graduate School and must be received by March 1 to be considered for the following fall, winter, and spring.

FELLOWSHIPS FROM FOUNDATIONS AND INDUSTRIES—At least 90 such fellowships, with various stipends, are awarded through the individual departments. Information and application forms may be secured from the head of the major department concerned. The fellowships which are awarded will vary somewhat from year to year, but the following are typical of those which were available for 1962-63:

AMERICAN CHEMICAL SOCIETY (PETROLEUM RESEARCH FUND)—Open to graduate students in chemistry and chemical engineering; stipend $2,000-$2,400.

American Chemical Society (Petroleum Research Fund)—Open to graduate students in fuel technology; stipend $2,280.

American Chemical Society (Petroleum Research Fund) (2)—Open to graduate students in geochemistry, mineralogy, and solid state technology; stipend $2,400.

American Chemical Society (Petroleum Research Fund)—Open to graduate students in geology; stipend $2,400.

American Cyanamid Fellowship in Chemistry and Chemical Engineering—Open to a graduate student for the final year of study leading to the Ph.D. degree. Awarded in alternate years to a chemist and to a chemical engineer; stipend $1,800.

American Iron and Steel Institute (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400.

American Petroleum Institute Fellowships (5)—Open to graduate students in chemistry and physics for research concerning the synthesis and properties of high molecular weight hydrocarbons; stipend $1,710-$2,280.

American Petroleum Institute Fellowships (2)—Open to graduate students in geochemistry, ceramic technology, mineralogy, and solid state technology for research concerning the synthesis and properties of clays and related inorganic phases; stipend $2,280-$2,400.

American Petroleum Institute Drilling Research Fellowship—Open to graduate students in mining or petroleum and natural gas engineering for studies related to drilling and rock penetration; stipend $2,400.

American Zinc Institute Fellowship—In support of graduate research involving zinc or its compounds. Open to students in solid state technology, geochemistry, or allied fields; stipend $2,400.

American Zinc Institute Fellowship—Open to students in ceramic technology; stipend $2,000.

Armstrong Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry; stipend $640.

The Michael Baker, Jr., Fellowship in Public Administration—Available to a candidate for a master's degree in public administration; stipend $2,000.

The Caroline Capozzola Fellowship—Available to a candidate for a master's degree in public administration; stipend $2,000.

Carborundum Corporation Fellowship—Available to a graduate student in mineral preparation; stipend $2,400.

Continental Oil Company Fellowship—Available to graduate students in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

Continental Oil Company Fellowship in Petroleum Economics—Available to graduate students in mineral economics for studies in petroleum economics; stipend $2,280.

Diamond Alkali Summer Fellowship—Open to graduate students in chemistry; stipend $650.

Esso Research and Engineering Postgraduate Fellowship in Chemistry and Chemical Engineering—Open to advanced graduate students for one year of study leading to the Ph.D. degree; stipend $1,800-$2,400.

W. S. Elliott Fellowship—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

General Atomic Division of General Dynamics Corporation Fellowship—Open to graduate students in physics; stipend $2,500.

General Electric Foundation Fellowship—Open to graduate students in ceramic technology; stipend $2,400-$2,600.

General Foods Fund Fellowships (2)—For graduate work with a major in home economics; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

Gulf Oil Company Fellowship in Petroleum and Natural Gas Engineering—For graduate work in petroleum production; stipend $2,400.

Hamilton Standard Fellowship—Open to graduates of this University in aero-

space, electrical, and mechanical engineering, engineering mechanics, and physics; stipend $1,800.

International Business Machines Corporation Fellowship—Open to an outstanding graduate student doing research in physical science or engineering; fellowship rotated annually among certain departments specified by the company; stipend $1,800-$2,500.

Kopper's Summer Supplemental Teaching Fellowships (2)—Open to graduate students in chemistry; stipend $600.

Lead Industries Association Fellowship—Open to graduate students in ceramic technology for studies of lead oxide systems; stipend $1,992.

Lead Industries Association Fellowship—Open to graduate students in geochemistry, mineralogy, and solid state technology; stipend $2,400.

Molybdenum Corporation of America—Open to a graduate student in mineral preparation; stipend $2,400.

Monsanto Summer Research Fellowships (2)—Open to graduate students in chemistry; stipend $650.

Edward Orton, Jr., Ceramic Foundation Fellowship—Open to students in ceramic technology for studies relating to kiln-fired ceramic bodies; stipend $2,400.

Owens-Corning Fiberglas Fellowship in Ceramic Technology—Open to graduate students in ceramic technology; stipend $3,000.

Owens-Illinois Fellowship—Open to graduate students in ceramic technology for studies in glass science and technology; stipend $3,000.

Pennsylvania Cooperative Wildlife Association (3)—Available to graduate students in forestry; stipend $2,280.

Pennsylvania Electric Company Fellowship—For graduate work in civil engineering on construction industry applications of fly ash; stipend $2,400.

Pennsylvania Natural Gas Men's Fellowship—For graduate work in petroleum and natural gas engineering for studies in gas technology; stipend $2,000.

Pennsylvania Power and Light Company Fellowship—Open to graduate students in mineral preparation; stipend $2,400.

Pfaudler-Permutit Fellowship—Open to students in ceramic technology; stipend $3,000.

Pittsburgh Plate Glass Fellowship—Open to graduate students in ceramic technology for fundamental studies of glass; stipend $3,000.

Radio Corporation of America Fellowship—Open to graduate students in electrical engineering; stipend $2,520.

Shell Fellowship in Chemical Engineering—Open to graduate students in chemical engineering for the final year of study leading to the Ph.D. degree; stipend $2,400.

Shell Fellowship in Chemistry—Open to a graduate student in chemistry; stipend $2,100.

Shell Summer Fellowships in Chemistry (4)—Open to graduate students in chemistry; stipend $750.

Socony-Mobil Oil Fellowship—Available for graduate students in chemical engineering; stipend $2,000.

Speer Carbon Fellowship—Open to graduate students in fuel technology for studies on carbon; stipend $2,400.

Stackpole Ferrite Fellowship—Open to students in ceramic technology and solid state technology; stipend $3,000.

Sprague Electric Company Fellowship—Open to students in ceramic technology and solid state technology; stipend $2,400.

Stauffer Chemical Company Fellowship in Chemistry—Open to a graduate student in chemistry for research on organometallic compounds; stipend $1,800.

Sun Oil Company Fellowship in Chemistry—Open to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

Texaco, Inc., Fellowship—Open to a graduate student in physics; stipend $3,000.

Union Carbide Metals Fellowship—Open to graduate students in metallurgy; stipend $2,280.

Union Carbide Summer Fellowships (4)—Open to graduate students in chemical engineering; stipend $300-$636.

U. S. Department of Health, Education, and Welfare: Vocational Rehabilitation Administration Traineeships in Speech Pathology and Audiology (11)—Open to graduate students majoring in speech pathology and audiology; stipend $2,400-$2,800.

U. S. Department of Health, Education, and Welfare: Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in Counseling in Education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

U. S. Public Health Service Traineeships in Clinical Psychology (12) and in School Psychology (3)—Open to selected graduate students in these areas of psychology; stipend $1,800-$3,000.

U. S. Public Health Service Traineeships in Microbiology—Open to selected graduate students in microbiology; stipend $2,400-$2,700.

U. S. Public Health Service Traineeships in Public Health Nutrition—Open to selected graduate students in foods and nutrition; stipend $3,000.

U. S. Public Health Service Traineeships in Zoology (4)—Open to selected graduate students in zoology; stipend $2,400.

United States Steel Foundation Fellowship—Open to graduate students in the College of Mineral Industries for studies related to steel-making; stipend $2,880.

Veterans Administration Internships in Clinical Psychology (18)—Open to selected advanced graduate students in this area of psychology.

Wheelabrator Fellowship—Open to graduate students in industrial engineering, mechanical engineering, and metallurgy; stipend $1,500.

In addition, numerous grants are available from governmental agencies, industrial concerns, and foundations for the support of investigations of particular problems. Many of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY ADMINISTERED FELLOWSHIPS—Attention is directed to the following fellowships which are awarded nationally:

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelors' degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee.

National Aeronautics and Space Administration Predoctoral Traineeships in Space-Related Science—The National Aeronautics and Space Administration awards training grants to various recognized universities to increase the supply of scientists and engineers in space-related science and technology in order to meet the growing needs of the federal government's space research program. These grants permit a university to award a specified number of traineeships in science and engineering fields. The awards compare favorably with the best fellowships. In 1963-64 the University had 10 of these traineeships in physical science and engineering fields.

More may be available for 1964-65. No institution will know whether it has any available until late in the fall. Applicants should write to the graduate dean at the institution of their choice, or to the head of the department in their graduate field.

National Defense Graduate Fellowships—Under Title IV of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education makes an allotment of fellowships to certain approved new or expanded doctoral programs. The purpose of these three-year awards is to assist able beginning graduate students in obtaining their doctorates (with preference given to those interested in teaching in institutions of higher education) and to distribute graduate study facilities geographically. The University has had some of these fellowships in certain areas in past years.

No institution will know until about December 15 whether it will have any fellowships under this program for 1964-65. A federal announcement booklet is sent to all colleges about the first of the year, listing the institutions which have fellowships in various fields. A senior should inquire from the dean of his college. Application is made directly to the graduate deans of the institutions having programs in the desired field. Most institutions have application deadlines from February 15 to 20.

National Science Foundation Cooperative Graduate Fellowships—The Graduate School participates in this program of fellowships available in the biological, engineering, mathematical, and physical sciences, anthropology, economics (excluding business administration), geography, history and philosophy of science, psychology (excluding clinical), and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, and meteorology. Applications for the following year must reach the Dean of the Graduate School by November 1.

National Science Foundation Graduate Fellowships—These fellowships, which are somewhat different from the NSF Cooperative Fellowships mentioned above, are also awarded for graduate study in the biological, engineering, mathematical, and physical sciences, anthropology, economics (excluding business administration), geography, history and philosophy of science, psychology (excluding clinical), and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, and meteorology. These fellowships are used at the university of one's choice. Application is made during the fall to the National Science Foundation, Washington 25, D. C. The application deadline is usually about January 1.

U. S. Public Health Service Predoctoral Fellowships—Available to graduate students in the basic sciences, such as biology, chemistry, zoology, physiology, biochemistry, etc., as they relate to problems of health and disease; and among the social sciences, those areas, such as psychology and sociology, which relate to the problems of health and disease and some interdisciplinary fields such as biostatistics, medical economics, cultural anthropology, etc. These fellowships are used at the university of one's choice, and application should be made to the Career Development Review Branch, Division of Research Grants, National Institutes of Health, Bethesda, Maryland, by October 1, February 1, or May 1 to be considered at the December, April, or July review periods respectively.

Woodrow Wilson National Fellowships—Awarded by the Woodrow Wilson National Fellowship Foundation for first year graduate study at the institution of one's choice, to outstanding students who show a clear preference for a career in college teaching, especially in the areas of the humanities and social sciences. In exceptional cases consideration will be given to students in the natural sciences.

A student must be nominated by a professor in his undergraduate college, the nomination being sent to the regional chairman of the Woodrow Wilson Fellowships for the area in which that college is located. Applicants should consult the dean or other

official of their college or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J. Nominations must reach the regional chairman by October 31.

OTHER AIDS

COUNSELORSHIPS FOR MEN—A number of appointments are available to men graduate students to serve as Resident Counselors in the undergraduate residence halls for men. A counselor's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training in personnel work is desirable, though not essential.

These appointments are for three terms (fall, winter, and spring) and provide the recipient with room and board and a grant-in-aid for full tuition. A more limited number of appointments are available during the summer term. A counselor may not hold a fellowship or assistantship during the term of his appointment as a counselor. He may not engage in any other form of part-time employment. He may carry 7 to 9 credits per term.

Requests for information and application forms should be addressed to the Dean of Men.

SENATORIAL GRANTS—The University makes available annually a quota of 24 one-year (three-term) grants to each State Senator and to the Governor and the Lieutenant Governor. Each grant has a value of $35 per term or $105 for each three-term combination. Any undergraduate or graduate student who is a full-time student according to the regulations of his academic level is eligible to receive one of these grants. Nominations for these grants may be made by the above State officials at any time after March 1, for the three-term period which may begin in June or September as the student desires. The recipient is expected to maintain attendance and satisfactory scholarship or the grant will be canceled. The grant is applied to the reduction of the student's bill for the respective terms.

Any student interested in receiving this type of aid should contact the State Senator in his senatorial district or the Governor or the Lieutenant Governor.

SENIOR RESIDENT POSITIONS FOR WOMEN—Full-time salaried appointments as Senior Residents in undergraduate halls for women are available to qualified women graduate students. Responsibilities include working with student groups in a programming capacity, counseling, and supervising the residence hall during the evening.

These positions permit the holders to take 4 graduate credits per term at $5.50 per credit. Appointments are made for the fall, winter, and spring terms. Special arrangements of hours of work and credits may be made for the summer term. It is thus possible to complete work for a master's degree in nine terms.

Requests for information and application forms should be addressed to the Dean of Women.

GRADUATE GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on the basis of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed 10 hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $175 per term, to non-Pennsylvanians, $350 per term.

Applications should be addressed to the Dean of the Graduate School and must be received by March 15 to be considered for the following summer or fall.

DU PONT TEACHING AWARD IN CHEMISTRY—To be eligible for the E. I. du Pont de Nemours and Company Postgraduate Teaching Assistant Award, a graduate student must be currently serving as a part-time teaching assistant and preferably should have had two years of experience in this capacity. The recipient receives $1,200 in addition to the regular stipend paid him as a teaching assistant.

JOHN W. WHITE FELLOWSHIP—Awarded to two graduates of The Pennsylvania State University each year on the basis of scholarship, need, character, and attitude. The recipients may enroll in any approved college or university.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded annually through individual departments. A request for information should be directed to the department head in the field of the student's major interest.

A.A.U.W. SCHOLARSHIP—The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

GENERAL LOAN FUNDS—Such funds are available from two sources: (1) University loan funds, in limited amounts; (2) loan funds received by the University under Title II of the National Defense Education Act of 1958. Graduate students who are classified as full-time students by the Dean of the Graduate School are eligible for a loan. Information and application forms may be obtained from the Director of the Office of Student Aid, 218 Willard Building.

ASSURED EDUCATION PLAN—The University offers to the parents (or guardians) of students the Assured Education Plan, enabling them to pay University bills out of current income on a monthly basis. It is available to parents residing anywhere in the United States. There are two plans, one covering a single year's expenses, the other covering two to five years' expenses in a single contract. Life insurance and total and permanent disability insurance are a part of the plan for a parent up to his 65th and 61st birthdays respectively.

In the one-year plan repayment may be made in 8, 10, or 12 monthly payments, the credit service charge being 2⅔ per cent, 3⅓ per cent, or 4 per cent respectively. The charge for the insurance is 62 cents a month for each $1,000.

Under certain conditions graduate students may sign their own agreements under the one-year plan only. The student, or spouse, if any, must be at least 21 years of age, employed, and furnish credit information. If married, the spouse must sign the agreement with the student. Repayment must be made in one year, except for terminal year students, who may have 24 months for repayment. Further information and application forms may be obtained from the Office of the Bursar.

GRADUATE SCHOOL EMERGENCY LOAN FUND—This fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School alumni who have received their bachelor's degrees elsewhere. The Graduate Student Association recently made a sizable contribution to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and microfilming fee, job interview travel, etc.

Loans may not exceed $200. The fund is administered by the Dean of the Graduate School, and application forms may be obtained at his office.

STUDENT EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly.

A student who holds a graduate assistantship or a fellowship may not accept em-

ployment, either at the University or elsewhere, during the period of his appointment, except as stipulated in certain foundation and federal fellowship programs.

The Office of Student Aid, 218 Willard Building, offers assistance to students in finding part-time employment in town as well as on the campus.

VETERANS BENEFITS—The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws.

Under Public Law 550, a student is classified as to his rate of training on the basis of the type of program he is following and the number of credits for which he registers.

STUDENT SERVICES

HEALTH CENTER—The services of the Ritenour Health Center are available to graduate students registered for 8 or more credits and to all graduate assistants, fellows, and other holders of graduate tuition grants.

Students are entitled to five days' free treatment in the University Hospital each term. For each day of confinement in excess of five days a charge of $10 will be made. Almost all modern drugs are furnished free of charge as required for treatment, but the student may be charged extra for medication where such treatment is unusual or extremely expensive. Consult the *Manual for Graduate Students* for details concerning facilities and services.

INSURANCE PLAN—A voluntary Accident and Sickness Insurance Plan with a variety of benefits is available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center. The Student Government Association, which operates the plan, has offices in Room 203A Hetzel Union Building, University Park, Pa., 16802. Telephone: Area Code 814, 865-4952.

PLACEMENT SERVICE—The University Placement Service coordinates the placement activities of all the Colleges and the Graduate School. It is available to any student who is in need of counseling or guidance on employment problems. The services of the following sections are available to the student without charge.

The General Placement Section functions primarily as a clearing house, bringing together students, alumni, faculty members, and representatives of organizations that are seeking college-trained personnel. Summer jobs other than those at camps or resorts are listed at this office.

The Teacher Placement Section assists seniors, alumni, and graduate students in all departments in securing teaching positions.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths serve the student body. Many other religious organizations, including denominational and interdenominational groups, are active on the campus and in association with local churches.

STUDENT AFFAIRS—The Graduate Student Association is the official University-wide organization of graduate students. All students have membership in the Association, which promotes the general welfare and the academic interests of graduate students. It publishes the *Graduate School Newsletter*, helps to sponsor the Graduate School lecture series, and sponsors social functions.

MASTERS' DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees: academic and professional. Of the eight masters' degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Forestry, and Master of Public Administration.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION—Adequate undergraduate preparation is required in the field in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of field and can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. An applicant who meets the minimum grade point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the minimum period of residence. An applicant for admission to the M.Ed. program is required to have had at least 18 credits in education and related psychology, and in certain major fields may be required to have had practice teaching.

After a student has been admitted as a regular graduate student, he should confer with the head of his major department concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department.

M.A. AND M.S.—SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus. A candidate must present a major and either a minor field of study or an approved group of general studies. A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to but different from that of the major. A general studies group consists of no fewer than 6 credits in fields other than that designated as the major field and considered by the major department to have significance and value for the candidate.

At least 18 credits in the 500 and 600 series combined must be included in the

program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major field. A thesis is required of all candidates for the degree of Master of Science and of most candidates for the degree of Master of Arts. Details are given in the introductory paragraphs under the major field headings in the latter part of this bulletin. If a student is required to write a thesis he must complete at least 6 credits of thesis research (600 or 610).

Those candidates who are not required to write a thesis must present a suitable essay or term paper. Its nature and extent shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The department may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off-campus. To do so he must make satisfactory arrangements in advance with both the major department and the Dean of the Graduate School.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

M.Agr.—SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Agriculture has a professional orientation and provides training for increased competence in the various fields of agriculture. It should be clearly distinguished from the research-oriented program which leads to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus.

A candidate is required to earn at least 12 credits in graduate courses (500 level) and a minimum of 12 credits outside his major field.

In addition to credit requirements, a candidate must present a paper on a selected professional problem comparable in quality to a thesis in which he applies scientific methods to the solution of a problem. Ability must be demonstrated to (a) formulate and state meaningfully the problem and objectives, (b) critically analyze the present state of knowledge of the problem, (c) acquire and analyze information to help solve the problem, (d) draw logical conclusions, and (e) interpret the relationship between the findings and professional problems. The paper will be evaluated by a committee appointed by the Dean of the Graduate School.

The candidate is required to pass a final examination administered by a committee of three faculty members appointed by the Dean of the Graduate School with at least one member from a department other than that of the candidate's major field.

M.B.A.—SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Business Administration is designed to develop advanced professional competence in the various fields of business administration. It should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Science and Doctor of Philosophy with a major in Business Administration.

The program requires a minimum of 36 graduate credits of which at least 18 must be at the 500 level and at least 26 must be earned on the University Park Campus. Candidates who enter this program without undergraduate training in business administration may be required to take up to 21 credits of preparatory courses.

Moreover, a candidate is required to present a project paper, comparable in quality and scope of work to a graduate thesis, concerning a problem of a company.

After substantially completing his course requirements, a candidate must pass a comprehensive examination to be administered by a committee composed of graduate faculty members, the first part being written and the second part oral. During these examinations the candidate will be expected to demonstrate his ability to integrate the knowledge gained in the several functional areas of business in a manner which reflects a broad knowledge of his professional responsibilities.

Applicants for the various graduate programs in business administration are required to take the admission test for graduate study in business given by the Educational Testing Service.

M.Ed.—SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Education provides preparation for increased professional competence in the several fields of eduaction. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts or Master of Science. The requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned on the University Park Campus and at least 24 must be in course work.

At least 15 credits in 500 series courses is required except in those fields for which the Dean has approved the waiving of this requirement for an experimental period of five years.

MAJORS IN THE FIELDS OF EDUCATION—A student may major in one of the approved fields of education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate department of education.

A program of this type requires at least 6 credits to be earned outside the fields of education.

MAJORS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as chemistry, mathematics, or German, may choose such a field as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose such a major as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major. In this case the student will be expected to choose one field in the area as a primary interest and devote at least 12 credits to it.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits will probably be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology. However, if his educational foundations background is judged to be adequate, the candidate may be approved for work in any field of education.

THESIS OR TERM PAPER—Six credits may be granted for an approved thesis. Those candidates who do not elect to write a thesis are required to present an essay or term paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major department. The department shall report

to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department to require one or more copies of such an essay for its library or other files.

M.Eng.—SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Engineering provides training for advanced professional competence in the several fields of engineering. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which at least 12 must be earned in graduate courses (500 series), and at least 6 must be earned outside the candidate's field of concentration.

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Pennsylvania State University graduate center other than University Park.

M.F.—SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Forestry provides training for increased professional competence in the several specialized areas of forest resource management and forest products. It should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Science with a major in forestry.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to prepare and submit an acceptable thesis. At least 6 credits of thesis work is required.

M.P.A.—SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration at local, state, national, and international levels or with private and voluntary agencies. This program should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may also specialize in public administration.

For the M.P.A. degree a minimum of 36 graduate credits is required of which at least 6 must be devoted to either a thesis or an internship. Students with extensive government experience will write a thesis; others will serve an internship and write

a critical review of the experience, the review to be comparable in quality to a thesis. A comprehensive final examination will be required of all students, the examination to be written, oral, or both.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervising committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Pennsylvania State University graduate center other than University Park.

The degree is a terminal one and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred. The two programs are recognized as different in purpose and consequently have different requirements in certain respects.

ADMISSION—A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major field in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department and is given near the end of the first, or at the beginning of the second, year of graduate work including that done for the master's degree and work done elsewhere as well as here (i.e., at about the time he has earned a total of 30 graduate credits).

A new student transferring from another graduate school with 30 or more transfer credits must take this examination before he has earned more than 10 credits here.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure the attainment of the doctorate. The general requirements are based upon a period of residence, the passing of comprehensive examinations, and the writing of a satisfactory thesis. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student. It includes work in a major field of study and in either a minor field or a group of general studies.

A master's degree is not a prerequisite for the doctorate. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research, or their equivalent in credits, is required for a doctor's degree. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study. The D.Ed. candidate may meet the residence requirement by enrollment in the summer terms, but increasingly departments are insisting upon the same requirements as for the Ph.D.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits

per term and three such terms will meet the minimum residence requirement for the Ph.D.

OFF-CAMPUS AND TRANSFER CREDITS—A maximum of two full academic years of work in another approved school granting the doctorate in the major field may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. Not more than one year of work at a graduate school not granting the doctorate in the major field will be accepted here to apply toward doctoral degree requirements. Credit for courses and research work done elsewhere can be used to meet degree requirements, however, only if the work is appropriate to the candidate's proposed program of study as determined by his doctoral committee.

By securing the maximum allowable number of transfer credits, it is possible theoretically to complete the requirements at this institution in three terms. In practice, however, this is rarely possible because of the sequence required in courses and examinations, special departmental requirements, and the possibility of protracted research. It must be remembered that the quality of the program rather than the time requirement is of paramount concern.

Subject to the approval of his adviser, the head of his major department, and the Dean of the Graduate School, a student may register for research to be done away from the University Park Campus. Such work will not be approved, however, simply because the arrangement is convenient for the student; scholarly considerations must determine the choice of location. A doctoral candidate may register for a maximum of 30 credits of research in absentia, but these credits must be included in the 60 credits which a candidate may earn in study away from the University Park Campus. The maximum load permitted a student who is employed full time is 4 credits in a term.

With the approval of his committee, a candidate may apply toward the minimum requirements of a doctor's degree a maximum of 10 credits earned in Continuing Education classes or at the Commonwealth Campuses of The Pennsylvania State University. Credits so earned as a part of a master's degree program must be included in the limit of 10.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted as a regular graduate student, he should confer with the head of his major department concerning departmental procedures and the appointment of an adviser. The arrangement and approval of the details of the term-by-term schedule of the student is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major department for this specific duty.

The general guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of five or more members of the Graduate Faculty. The committee is appointed by the Dean of the Graduate School, upon recommendation of the head of the major department, at the time the student is admitted to candidacy. The chairman of the committee must hold senior membership in the Graduate Faculty. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. At his discretion, the Dean may add other members to the committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after admission to candidacy. The committee will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his

comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

LANGUAGE EXAMINATIONS—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School and must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must show either a reading knowledge of two other languages or a reading, writing, listening, and speaking knowledge of one other language. The languages used to satisfy this requirement must have significance in the candidate's field of study and be approved by the candidate's doctoral committee and the Dean of the Graduate School. French, German, and Russian are the languages most frequently needed and will be approved by the Dean without specific request. The use of any other language must be approved in advance.

When competence in two languages is offered in fulfillment of the requirements, the student is urged to complete one-half of the requirement before admission to candidacy and is required to complete the whole requirement before taking the comprehensive examination. If the candidate elects to demonstrate a reading, writing, listening, and speaking knowledge of one language, he is required to demonstrate competence in two of the four skills before admission to candidacy and in all four before taking the comprehensive examination.

Registration for both types of examination occurs at the beginning of the term, the specific date being given in the calendar. An applicant for an examination in reading competence is required to present himself to the language department concerned for a preliminary test in oral translation, not to exceed 15 minutes' duration during the registration period of one of the terms. A student who makes a very poor showing in the preliminary test will not be permitted to register for the next examination and may be required to take another preliminary test.

The examinations in reading competence are administered by the respective language departments and are held four times each year. Specific dates may be obtained from the calendar. The examination, which is to be written and to be completed with the aid of a dictionary, is one hour in length. The text for translation shall be a periodical article selected by the examining department from five articles in the candidate's field of specialty and recommended by his adviser or department head. Each of the articles recommended shall be not less than 500 words in length.

Administration of the examinations designed for demonstration of a reading, writing, listening, and speaking knowledge of a language other than English is vested in two members of each of the foreign language departments. Immediately upon registration the candidate is assigned by the examiners a work of considerable length unrelated to the area of his specialty; discussion of this work with the examiner six weeks later in the language in which it is written will serve to determine the candidate's broad, idiomatic grasp of the language. Subsequently, the candidate will be required without prior preparation to write in the same language a summary of the contents of a shorter document in the area of his specialty. For this purpose his adviser or department head is expected to recommend to the examiners five articles of at least 500 words in length, the titles of which are not known to the student, from which they will select the one to be employed. All arrangements for the examination are to be made in the language in which competence is to be demonstrated.

In general, the language requirements must be met at this University. However, if a student has passed suitable language proficiency examinations at another institution prior to admission to the Graduate School at Penn State, this may be accepted under certain circumstances in satisfaction of requirements here. A letter of certification from the Graduate Dean of the other institution will be required.

Candidates for the D.Ed. degree may be required by their major departments to demonstrate competency in foreign languages, but there is no Graduate School requirement.

COMPREHENSIVE EXAMINATIONS—A candidate for the Ph.D. or D.Ed. degree is required to take a comprehensive examination covering his major and minor fields to determine if he has adequate mastery of the subject matter to entitle him to proceed to the completion of a thesis.

This examination will normally be taken when the candidate has substantially completed his course work. It is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. In no case may the final examination be scheduled less than three months after the comprehensive examination. The comprehensive examination is given and evaluated by the doctoral committee and may be either written or oral, or both. A favorable vote of at least two thirds of the members of the committee is required for passing. In case of failure, it is the responsibility of the doctoral committee to determine whether he may take another examination. The results are reported to the Dean of the Graduate School.

A candidate for the degree of Doctor of Philosophy must have satisfied the language requirements before taking the comprehensive examination.

FINAL ORAL EXAMINATIONS—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. In no case may the final examination be scheduled less than three months after the comprehensive examination. The deadline for holding the examination is three weeks before Commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the whole field of study of the candidate without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

TIME LIMITATION—All requirements for the degree of Doctor of Philosophy must be met within seven years from the time of admission to doctoral candidacy. This limitation applies to all candidates who were officially admitted to candidacy after June 1, 1963.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal on the part of the candidate an ability to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than two weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate, such as biological science, foods and nutrition, or English.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) the satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

MAJOR AND MINOR FIELDS—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major field of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes the following specific courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education: Ed.Psy. 414, 490, 494, 590; Ed.Ser. 417, 418, 516, 517, 522; and Psy. 502, 513, 514.

A candidate choosing a major in one of the fields of education must also choose either a minor or a group of general studies with the approval of the major department. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside the fields of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside the fields of education considered by the major department to have significance and value for the candidate.

COMPREHENSIVE EXAMINATIONS—In addition to demonstrating a high level of competence in the subject matter of his major and minor fields, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessasry and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scien-

tific controls. The thesis may be based upon a product or project of a professional nature, provided that scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than two weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

PROGRAMS AND COURSES

Programs of study leading to advanced degrees are offered in many major and minor fields which are listed in the following section, and the major fields are summarized on page 58. Related courses are grouped together under the name of the field. To locate a particular course or group of courses, consult the index.

In general, departments of the University are identified with specific major fields. Thus aeronautical engineering is a major field of study which is offered under the supervision of the Department of Aeronautical Engineering. On the other hand, biological science and comparative literature are major fields for which there are no corresponding departments. In such cases a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one field. Thus the Department of Civil Engineering offers work in both civil and sanitary engineering.

Applicants for admission are encouraged to consult the person whose name is listed under the major field heading.

DEGREES—In those major fields approved for the doctorate, the Ph.D. is normally conferred, although a program leading to the D.Ed. may also be arranged with the consent of the department or committee in charge if such a professional program is appropriate. Similarly, in major fields approved for the master's degree the M.A. or M.S. is normally conferred, but a program leading to the M.Agr., M.B.A., M.Ed., M.Eng., M.F., or M.P.A. may also be available. The D.Ed. and M.Ed. are not limited to the fields of education, but with the consent of the department or committee in charge may be offered in any approved major field appropriate to the preparation of teachers, such as mathematics or English. In this case the program is sponsored by a major department outside the fields of education, such as the Department of Mathematics, but the student's minor is in education.

MINOR FIELDS—All major fields listed are also acceptable as minors. In addition, a few fields in which no advanced degrees are offered have been approved as minors for candidates who are majoring in related areas. Such minor fields are identified in the summary on page 58 and by a brief statement under the field heading in the following section.

A candidate's choice of minor field depends upon the particular degree he is seeking and is subject to the approval of his major department. The requirements in each minor field are established by the minor department subject to the regulations of the Graduate Faculty.

INTERDISCIPLINARY MAJORS—In addition to the majors listed on the following pages, interdisciplinary majors involving two or more departments may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental committees.

OTHER FIELDS—Fields which have not been approved for either major or minor work, but in which approved courses are offered, are listed at the end of this bulletin. These courses may be used in graduate programs as electives or as part of a general studies program, subject to the approval of the major department and to the restrictions upon the use of 400 series courses in degree programs.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses

may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 45 to 49 under the specific requirements for the various masters' degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.5, and other students who have been granted permission to enroll by the Dean of the Graduate School.

Course numbers 600 and 610 apply to thesis research and are available only to students registered in the Graduate School.

CREDITS—A credit is defined as a unit of time approximately equivalent to one week of full-time graduate study. Accordingly, a full-time student having no concurrent employment may earn a maximum of 10 credits in a 10-week term. A "credit" as used in this bulletin, therefore, is identical in meaning with a "semester credit" and should not be confused with a "quarter credit" which is associated with the traditional quarter system. By increasing the length of class periods to 75 minutes, the Penn State calendar based upon a 10-week term provides for the same amount of time in a given course as does the typical semester plan.

COURSE DESCRIPTIONS—A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department offering the course.

A department may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400 and 500 series courses a department may schedule an individual student for fewer credits than the maximum number but in no case for more than the maximum number authorized.

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Timetable*, which is available at nominal cost from the Scheduling Office approximately six months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

RESEARCH AND THESIS WORK—In general, students registering for work on a master's or a doctor's thesis will, if it is to be done on the University Park Campus, use course number 600 preceded by an abbreviation designating the major field. Thus Aro.E. 600 signifies thesis research in aeronautical engineering. In case such work has been authorized for students not working on the University Park Campus, the number 610 will be used. Credits will be 1 to 10 per term.

It should be assumed that the numbers 600 and 610 are available in all fields in which majors have been approved for advanced degrees although these numbers may not appear in the timetables.

MAJOR and MINOR FIELDS

GRADUATE FIELDS OF STUDY

Aeronautical Engineering—Ph.D., M.S., M.Eng.*
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—M.S.
Agronomy—Ph.D., M.S., M.Agr.
Animal Husbandry—Ph.D., M.S.
Animal Nutrition—Ph.D., M.S.
Anthropology—M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A.
Art Education—Ph.D., D.Ed., M.S., M.Ed.
Art History—M.A.
Biochemistry—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Business Education—Ph.D., D.Ed., M.S., M.Ed.
Ceramic Technology—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S.
Chemistry—Ph.D., M.S., M.Ed.
Child Development and Family Relationships—Ph.D., D.Ed., M.S., M.Ed.
Civil Engineering—Ph.D., M.S., M.Eng.
Clothing and Textiles—Ph.D., D.Ed., M.S., M.Ed.
Comparative Literature—Ph.D., M.A.
Counseling in Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Earth Sciences—M.Ed.
Economics—Ph.D., M.A.
Educational Administration—Ph.D., D.Ed. M.S., M.Ed.
Electrical Engineering—Ph.D., M.S., M.Eng.*
Elementary Education—Ph.D., D.Ed., M.S., M.Ed.
Engineering Mechanics—Ph.D., M.S., M.Eng.
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S.
Extension Education—M.Agr., M.Ed.
Family Economics and Home Management—Ph.D., D.Ed., M.S., M.Ed.
Food Service and Housing Administration—M.S., M.Ed.
Foods and Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Forestry—M.S., M.F.
Fuel Technology—Ph.D., M.S.
General Family Studies—Ph.D., D.Ed., M.S., M.Ed.
Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Art (minor only)
Horticulture—Ph.D., M.S., M.Agr. M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—M.S., M.Eng.
Journalism—M.A.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.*
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Preparation—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S.
Music—M.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., D.Ed., M.S.
Public Administration—M.P.A.
Romance Languages and Literatures—Ph.D., M.A.
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
Solid State Technology—Ph.D., M.S.
Speech—Ph.D., D.Ed., M.A., M.Ed.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics (minor only)
Theatre Arts—M.A.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

The degrees listed above are the ones normally conferred in each of the designated major fields. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above fields in which a master's degree is conferred provided the field is appropriate to the preparation of teachers.

*Not offered on the University Park Campus.

Courses in Major and Minor Fields

AERONAUTICAL ENGINEERING

GEORGE F. WISLICENUS, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus)
Graduate Faculty: Professors Lumley, McCormick, and Wislicenus; Associate Professor Holl; Assistant Professor Rodgers.

Opportunities are available for graduate study in the following and related areas: modern fluid mechanics and physics, the interaction of fluids with solids, and the application of these disciplines to the design of devices and to the environment in which they operate. These topics are specifically included: cavitation, magnetohydrodynamics, the stability of laminar motions, turbulence, aero- and hydroelasticity, stability and control of vehicles, turbomachinery, V/STOL aircraft, high lift devices, and ground effect machines.

The entering student must hold a bachelor's degree in science, mathematics, or engineering and may be required to complete (without graduate credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so.

AERONAUTICAL ENGINEERING (ARO E)

401a,b,c. AERONAUTICAL ENGINEERING PROJECTS (2-12)
402. PROPULSION SYSTEMS DESIGN (2)
404. AIRPLANE AND MISSILE DESIGN (2)
407. AERODYNAMICS OF V/STOL AIRCRAFT (3)
408. AERONAUTICAL AND ASTRONAUTICAL TURBOMACHINERY (3)
410. AIRCRAFT AND SPACE PROPULSION (3)
411. AEROELASTICITY (3)
412. AERODYNAMICS OF VISCOUS FLUIDS (3)
413. STABILITY AND CONTROL OF AIRCRAFT AND MISSILES (3)
414. ADVANCED GASDYNAMICS (3)
415. ADVANCED THEORETICAL FLUID DYNAMICS (3-6)
416-417. AEROSPACE UNDERGRADUATE THESIS (2 each)
418. AEROSPACE SYSTEMS ENGINEERING (3)
420. PRINCIPLES OF FLIGHT TESTING (3)

501. STABILITY AND CONTROL (3) Formulation and methods of solution of stability and control problems dealing with airplanes, missiles, and space vehicles.

503. ELECTROMAGNETICALLY AND CHEMICALLY ACTIVE FLOWS (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. AERODYNAMICS OF V/STOL AIRCRAFT (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aro.E. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Perfect Fluid Theory A (3) Mathematical review, equations of motion and general consequences, application of complex variables to two-dimensional flow, conformal representations, Stokes' stream function.

509. Perfect Fluid Theory B (3) Review of axisymmetric motion; two-dimensional vortex motions; motions with cylindrical, spherical geometry; Bessel, Legendre functions; vortex motions in space. Prerequisite: Aro.E. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory, Prandtl-Meyer flow, method of characteristics.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

513. Turbulence and Related Topics (3) One or more of the following: stochastic processes, homogeneous turbulence, driven turbulence, noise and waves generated by turbulence, turbulent transport.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

520. Selected Topics in Aeronautical Engineering (1-12)

AGRICULTURAL ECONOMICS

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Barr, Becker, Bennett, Brandow, Butz, Frey, Hutton, Pasto, Pierce, Southworth, and Trotter; Associate Professor McAlexander.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

AGRICULTURAL ECONOMICS (AG EC)

407.	Advanced Farm Management (3)	*Mr. Hutton*
420.	Agricultural Prices (3)	*Mr. Bennett*
421.	Land Economics (3)	*Mr. Frey*
426.	(A.H. 426) Livestock Marketing (3)	*Mr. Trotter*

500. Seminar in Agricultural Economics (1-6) Review of current literature and problems.

503. Research Methods in Farm Management (1-3) Evaluation of research procedures, methods, results, and needs in the field; emphasis on their application to specific research problems. Prerequisites: Ag.Ec. 6, Econ. 14.
Mr. McAlexander

504. Agricultural Price and Income Policy (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405.
Mr. Brandow

505. Advanced Agricultural Statistics (3) Multiple correlation, curve fitting, analysis of variance, selection of samples, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

506. Economic Problems in Marketing Specific Agricultural Products (3) Profit maximization; psychological and sociological aspects of selling; engineering aspects of cost reduction; techniques in developing information for managerial decisions.

507. Seminar in Farm Management (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

510. Advanced Farm Finance (1-3) Problems and policies in agricultural credit, insurance, and farm financial management. *Mr. Hutton*

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

517. Problems and Policies of Farmer Cooperatives (3) Specific types of cooperative organizations, their problems, policies, and progress; relationships existing among cooperatives, between cooperatives and other business organizations, and between cooperatives and the public. Prerequisite: Ag.Ec. 17. *Mr. Becker*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. *Mr. Brandow*

522. Advanced Farm Appraisal (2) Land value theory; methods of land valuation; field practice in farm appraisal. *Mr. Pasto*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences.

526. Research Methods in Agricultural Economics (2) Application of economic and statistical principles.

534. Agricultural Production Economics (3) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change.
Mr. McAlexander

535. Seminar in Agricultural Marketing (2) *Mr. Southworth*

536. Seminar in Dairy Economics (1 per term) *Messrs. Pierce and Butz*

AGRICULTURAL EDUCATION

David R. McClay, *Head of the Department*
101 Agricultural Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors McClay and Stevens; Associate Professor Hoover.

Programs emphasize teacher education, supervision, and administration in agriculture and related fields. For admission a student must have 18 credits in professional education including educational psychology and practice teaching in vocational agriculture, or certification to teach vocational agriculture. Students who lack any part of these requirements may be admitted but are required to fulfill deficiencies without degree credit.

Minors may be taken in any of the areas of agricultural technology, or, for Master of Science and Doctor of Philosophy degree candidates, in one of the other fields of education, such as educational administration or higher education.

AGRICULTURAL EDUCATION (AG ED)

418v. Survey of Vocational Education in Agriculture (1-3) *Mr. Hoover*
420v. Advanced Visual and Other Sensory Aids in Teaching Agriculture (1-6) *Mr. Anthony*
422v. Supervision of Vocational Education in Agriculture (1-3) *Mr. Anthony*
424v. Occupational Guidance in Agricultural Industry (1-4) *Mr. Hoover*
426v. Young and Adult Farmer Education in Vocational Agriculture (1-4) *Mr. Stevens*
434v. Agricultural Developments (1-6) *Mr. Love*

501v. History of Agricultural Education (1-3) Development of training for agricultural vocations; emphasis upon introduction of agricultural instruction into the high school program. *Mr. Hoover*

502v. Teaching Vocational Agriculture (1-3) Organization of instruction with respect to vocational objectives, methods of presentation, supervision of practice, pupil evaluation of goals, and follow-up. *Mr. Stevens*

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation. *Mr. Stevens*

504v. Agricultural Education Seminar (1 per term) *Mr. McClay and Staff*

508v. State and County Administration and Supervision of Agricultural Education (1-3) Organization and administration of state, county, township, and district systems of agricultural education; state and federal legislation. *Mr. McClay*

509v. Teacher Training in Agricultural Education (1-6) Construction of college curriculums, courses of study, and organization of college departments for training agricultural teachers. *Mr. McClay*

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education. *Mr. Stevens*

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems. *Mr. Stevens*

524v. Annual Plan of Work (1-3) Detailed study of the agricultural education needs of each student's community and outlining annual plans of work. *Mr. Hoover*

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, technique of teaching, and measurements of results of teaching. *Mr. McClay*

AGRICULTURAL ENGINEERING

Frank W. Peikert, *Head of the Department*
204 Agricultural Engineering Building

Degree Conferred: M.S.
Graduate Faculty: Professors Bartlett and Peikert; Associate Professors Aldrich and Mohsenin.

Specialization is offered in farm power and machinery, electric power and processing, soil and water conservation engineering, and farm structures.

Prerequisite to major work is the completion of an undergraduate engineering curriculum from a recognized department.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Farm Structures (3)
404. Farm Machinery (3)
405. Advanced Farm Electrification (3)
406. Advanced Dairy Engineering (3)
407. Soil Water Engineering (3)
410. Farm Power (3)
420. Seminar (1)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY

Howard B. Sprague, *Head of the Department*
118 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Fortmann, Higbee, Hunter, Kardos, Matelski, Raleigh, Richer, H. B. Sprague, V. G. Sprague, Thomas, and Washko; Associate Professors Cleveland, Duich, Marriott, Pfeifer, and Starling; Assistant Professors Baker, Gorsline, Johnson, Marshall, and McKee.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures. Facilities are available for X-ray diffraction, infrared and petrographic investigations of soils.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

AGRONOMY (AGRO)

411. Breeding of Field Crops (3) *Mr. Thomas*
416a. Soil Characterization and Classification—Lecture (4) *Mr. Higbee*
416b. Soil Characterization and Classification—Practicum (1) *Mr. Higbee*
417. Forest Soils (3) *Mr. Matelski*
419. Soil Properties (4) *Mr. Baker*
422. Soil Conservation (3) *Mr. Kardos*
423. Pasture and Grassland Management (3) *Mr. Washko*
424. Fertilizer Technology (3) *Mr. Marriott*
425. Principles of Field Crop Production (3) *Messrs. Pfeifer and Gorsline*
431. Soil Fertility and Management (3) *Mr. Marriott*
438. Principles of Weed Control (3) *Mr. Raleigh*
490. Agronomic Problems (1-6) *Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Bot. 406. Winter term, odd years. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members. *Mr. H. B. Sprague*

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 417 or Chem. 23. Spring term, even years. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Phys. 215, Bioch. 425. Fall term, even years. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Bot. (Zool.) 422. Fall term, even years. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization and their applications to plant breeding. Prerequisite: Bot. (Zool.) 422. Fall term, odd years. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Math. 8 or Ag. 400. Fall term. *Mr. Starling*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. Winter term, odd years. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Bot. 406. Winter term, even years. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Bot. 406. Spring term, odd years. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 1, Chem. 13, G.Sc. 1. Winter term, even years. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. Winter term. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1-8 per term)

ANIMAL HUSBANDRY

Russell C. Miller
Head of the Department of Animal Industry and Nutrition
202 Armsby Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bortree, Henning, and Miller; Associate Professor Gobble; Assistant Professor Sherritt.

*Credits 1-6 per term.

A student may specialize in animal production, animal breeding, and meats. The prerequisite for major graduate work in animal husbandry is the completion of an undergraduate curriculum in animal husbandry or a related animal science area. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite course without degree credit.

ANIMAL HUSBANDRY (A H)

421. Advanced Meat Studies (3)
423. Advanced Livestock Selection (2)
424. Animal Husbandry Seminar (1)
426. (Ag.Ec. 426) Livestock Marketing (3)
431. Advanced Meat Selection and Grading (2)

500. Seminar in Animal Husbandry (1-6)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.H. 421.

503. Livestock Management (3) Handling of purebred herds and flocks; relation of livestock breeders to the public and methods of developing purebred herds and flocks through careful breeding.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: A.H. (D.Sc., Pty.Sc.) 322.

ANIMAL NUTRITION

Russell C. Miller
Head of the Department of Animal Industry and Nutrition
202 Armsby Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Barron, Bratzler, Henning, and Miller; Associate Professors Cowan, Hartsook, and Hershberger; Assistant Professor Long.

General nutrition, including energy metabolism, is emphasized in the graduate programs. For admission a student must have had courses in nutrition, organic chemistry, analytical chemistry, and calculus; and he must have had a total of at least 20 credits in chemistry and physics.

ANIMAL NUTRITION (A NTR)

401. Physiology of Nutrition (3) *Mr. Barron*
402. Energy and Protein Metabolism (3) *Mr. Barron*

ANTHROPOLOGY

Macklin E. John
Head of the Department of Sociology and Anthropology
240 Sparks Building

Degree Conferred: M.A.
Graduate Faculty: Professors F. R. Matson and Mook; Associate Professors Baker, Dupree, and Sanders.

Undergraduate preparation for this field must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences, with breadth of background preferably in the arts and sciences. With special permission exceptional students will be admitted provided they make up course deficiencies without graduate credit.

Sociology may be chosen as a minor field by students majoring in anthropology.

A thesis is required of all M.A. candidates in this field.

ANTHROPOLOGY (ANTHY)

401. Physical Anthropology: Human Evolution (3)
402. Human Ecology (3)
442. Anthropology of the New World (3)
443. Anthropology of the Old World and Middle East (3-6)
445. Primitive Society (3)
448. Anthropological Theory (3)

540. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

541. Research Methods in Anthropology (3-6) Principles, techniques, and examples of both field and library research in anthropology. Students will prepare research plans for class discussion.

545. Seminar in Antropology (1-9) Critical analysis of research in selected areas of anthropology. Prerequisites: Anthy. 45, 445.

ARCHAEOLOGY (ARCHY)

400-401. Archaeology of the Near East (3 each)
403. Archaeology of the New World (3)

ARCHITECTURAL ENGINEERING

Gifford H. Albright, *Head of the Department*
133 Hammond Building

Degree Conferred: M.S.
Graduate Faculty: Professor Richardson; Associate Professor Albright.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, computer application to building design and performance, or nuclear defensive and protective construction.

The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirements for protective construction.

For admission a student must have a strong background in some field of engineering: in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (4)
403. Architectural Engineering (3)
430. Architectural Engineering (3)
431. Architectural Engineering (3)
432. Architectural Engineering (4)
433. Architectural Engineering Thesis (2)
434. Architectural Engineering Thesis (2)
435. Architectural Engineering Thesis (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)
445. Architectural Engineering Seminar (1-6)
451. Fundamentals of Nuclear Defense Planning and Design (3)
464. Advanced Architectural Illumination Systems Design (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.
Mr. Richardson and Staff

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar. *Mr. Richardson and Staff*

504. Architectural Engineering (4-8) Statically indeterminate stresses in steel and reinforced concrete buildings; area moment, slope deflection, and moment distribution methods. Recitation and seminar. *Mr. Richardson and Staff*

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems. Prerequisite: graduate standing.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers. Prerequisite: graduate standing.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5, 451; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6) Prerequisite or concurrent: A.E. 451.

ARCHITECTURE

GREGORY AIN, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.
Graduate Faculty: Professors Hajjar and Hallock.

To enter graduate study in the field of architecture, a degree of Bachelor of Architecture, Bachelor of Science in Architecture, or Bachelor of Fine Arts in a five-year curriculum in architecture is required.

ARCHITECTURE (ARCH)

411. ADVANCED ARCHITECTURAL DESIGN (6)
412. ADVANCED ARCHITECTURAL DESIGN AND THESIS (5)
413. ADVANCED ARCHITECTURAL DESIGN AND THESIS (5)

501. ARCHITECTURAL DESIGN (4-8) Problems in advanced planning and design, including study of group composition. Practicum and seminar.

502. ARCHITECTURAL RESEARCH (2-12) Prosecution of assigned problems under the guidance of an instructor.

503. ARCHITECTURAL HISTORY RESEARCH (3-12) Original research in architectural history. Seminar and written reports. *Mr. Dickson and Staff*

ART

GEORGE S. ZORETICH, *Associate Head of the Department*
106 Temporary Building

Degree Conferred: M.A.
Graduate Faculty: Professors Heller and Zoretich; Associate Professors Altman and Pappas; Assistant Professor Shobaken.

Students may specialize in painting, printmaking, sculpture, or design. For admission at least 24 credits in studio art are required, and a portfolio of work must be presented. If an inadequacy exists in the student's undergraduate preparation, he will be required to make up the deficiency without degree credit.

A thesis is required of all M.A. candidates in this major.

ART (ART)

400. ADVANCED OIL PAINTING (3-12)
410. WATER-COLOR PAINTING: LANDSCAPE, STILL LIFE, AND FIGURE (3-9)
420. APPLIED DESIGN (3-9)
431. SCULPTURE (2-6)
440. PRINTMAKING (2-6)
490. LIFE DRAWING (3)

500. Art Research (2-6) Prosecution of assigned problems under the guidance of an instructor.

510. Advanced Painting (2-12)

531. Advanced Sculpture (2-12)

540. Advanced Printmaking (2-12)

ART EDUCATION

Edward L. Mattil, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Beittel and Mattil; Associate Professors Cataldo, Chomicky, Edmonston, and Pappas.

Graduate programs in this field prepare students for careers in public school art teaching, art supervision, college teaching, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree.

ART EDUCATION (A ED)

404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Methods in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

534. Creative Art Activity for the Handicapped (3) Specific methods for development of creative art activity with the physically, mentally, emotionally, and socially handicapped; adjustive effect upon them. Prerequisite: 6 credits in art education or 6 in special education or 6 in psychology.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

598. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

599. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 level, including A.Ed. 598.

ART HISTORY

Winston R. Weisman, *Head of the Department of Art*
116 Sackett Building

Degree Conferred: M.A.
Graduate Faculty: Professors Dickson, Hyslop, and Weisman; Associate Professor Enggass.

For admission at least 18 credits of undergraduate work in art are required. If an inadequacy exists, the student will be required to make up the deficiency without degree credit. Prior to graduation the candidate must demonstrate a working knowledge of at least one foreign language in his area of study.

A thesis is required of all M.A. candidates in this major.

ART AND ARCHITECTURAL HISTORY (A A H)

403. Studies in the Arts of the Middle Ages (3)
404. Theory and Form in Mannerist Art (3)
406. Movements in 19th Century European Art (3)
407. American Art of the Early Republic (3)
408. American Art from the Centennial to the Armory Show (3)
409. Movements in Contemporary Art (3-6)
410. Taste and Criticism in Art (3)
413. Problems in Art History (3-6 per term)
421. Contemporary Architecture (3)
448. History of Prints and Drawings (3)

502. Seminar in Medieval Art (3-6) Original research into problems dealing with the art of the middle ages.

503. Art History Research (3-6) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

504. Seminar in Renaissance Art (3-6) Investigations in the area of Renaissance art, centering around major masters and monuments.

505. Seminar in Baroque Art (3-6) Investigations in the area of Baroque art centering around major masters and monuments.

506. Seminar in Modern Art (3-6) Lectures, readings, reports, and discussions in the field of modern art.

507. Seminar in Modern Architecture (3) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

508. Seminar in American Art (3-6) Studies in the field of American art involving original research.

ART—MUSIC—THEATRE (A M T)

400. Contemporary Forms in Art, Music, Theatre (3)

BIOCHEMISTRY

Howard O. Triebold, *Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Althouse, Boucher, Clagett, Frear, Guerrant, Mallette, Pritham, Sullivan, and Triebold; Associate Professor Shigley; Assistant Professors Mumma and Payne.

Opportunities for research and graduate study are available in plant metabolism and photosynthesis, intermediary metabolism, nucleic acids, proteins, carbohydrates, lipides, enzymes, vitamins and nutrition, clinical chemistry, endocrinology, and pesticides.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

BIOCHEMISTRY (BIOCH)

401. General Biochemistry (4) — *Mr. Clagett*
402. General Biochemistry (4) — *Mr. Clagett*
404. Food Chemistry (3-4) — *Mr. Triebold*
417. Biochemical Methods of Analysis (4) — *Messrs. Triebold and Mumma*
425. Biophysical Chemistry (4) — *Mr. Mumma*
426. Biocolloids (3) — *Mr. Mallette*
436. Physiological Chemistry (3) — *Mr. Pritham*
437. Physiological Chemistry (3) — *Mr. Pritham*
438. Clinical Methods (3) — *Mr. Pritham*
439. Problems in Biochemistry (1-12)

501. Enzymes (2) Investigations and theories concerning nature of enzymes, enzyme action, influence of chemical environment on enzyme action, and biological applications. Prerequisite: Bioch. 402 or 437. Fall term. *Mr. Clagett*

503. Biochemical Problems (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

505. Vitamins and Dietary Deficiency Diseases (2) Lectures, conferences, and assigned reading. Prerequisite: Bioch. 402 or 437. Fall term, odd years. *Mr. Guerrant*

507. Seminar in Biochemistry (1 per term)

510. Proteins, Amino Acids, and Peptides (2) Organic, physical, and biological chemistry of the naturally occurring compounds of this group. Prerequisites: Bioch. 425; 402 or 437. Fall term. *Mr. Mallette*

511. Carbohydrates (2) Chemical constitution and properties of carbohydrates; their metabolism in plant and animal organisms. Prerequisite: Bioch. 402 or 437. Spring term. *Mr. Mumma*

512. Lipides (2) Investigations on biochemistry of fats and related substances. Winter term. *Mr. Shigley*

516. Chemistry of the Pesticides (2) Lectures and assigned readings on the chemistry of insecticides, fungicides, herbicides, rodenticides, and related materials. Prerequisites: Chem. 31; Bioch. 402 or 437. Winter term, even years. *Mr. Frear*

517. Endocrine Secretions (2) Chemistry of hormones and their physiological significance. Prerequisite: Bioch. 402 or 437. Spring term, even years. *Mr. Pritham*

519. Intermediary Metabolism (3) Processes involved in the utilization of metabolites in plants and animals. Prerequisite: Bioch. 402. Spring term. *Mr. Mallette*

520. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on proteins and enzymes. Prerequisite or concurrent: Bioch. 501, 510. Fall term. *Messrs. Clagett and Mallette*

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipides and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512. Winter term. *Messrs. Shigley and Mumma*

BIOLOGICAL SCIENCE

Leon R. Kneebone, *Chairman of the Committee on Biological Science*
117 Buckhout Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biophysics, botany, entomology, genetics, microbiology, plant pathology, and zoology.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including at least one year of chemistry, and 18 credits in education, and related psychology. As many

as 6 credits may be made up as undergraduate deficiencies after the candidate is admitted to the Graduate School.

The candidate for the M.Ed. degree must take at least 24 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in educational foundations and a term paper are required.

A reading knowledge of one foreign language is required for the D.Ed. degree.

BIOPHYSICS

ERNEST C. POLLARD, *Head of the Department*
101 Walker Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Anthony, Ludwig, Mallette, and Pollard; Associate Professors Ginoza, H. Schraer, and Strother; Assistant Professors Person, R. Schraer, and Smythe.

This program is designed for those interested in applying physical methods to the problems of living systems. A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. Opportunity to make up possible undergraduate deficiencies is provided in the program.

Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by a committee. These include courses in physics, chemistry, biochemistry, zoology, and bacteriology.

BOTANY

ALVIN R. GROVE, *Acting Head of the Department*
206 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Fergus, Grove, Wahl, and Wright; Associate Professors Grun, Hill, Hillson, Kovar, and Schein; Assistant Professors Bell, Hamilton, and Hovin.

The student may specialize in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, or taxonomy. An entering student should present 27 credits of undergraduate work in botany or 21 credits in botany and 6 in biological science. As many as 6 credits may be made up as undergraduate deficiencies after the candidate has been admitted to the Graduate School.

In addition to its excellent facilities for research in various phases of botany and genetics, the department is equipped with a Gamma Radiation Laboratory for the study of irradiation effects upon plants and other facets of radiation biology.

See also "Plant Pathology" and "Genetics."

BOTANY (BOT)

400.	COMPARATIVE PLANT MORPHOLOGY (4)	*Mr. Hillson*
405.	(Zool. 405) GENERAL CYTOLOGY (3)	*Mr. Grun*
406.	PLANT PHYSIOLOGY (4)	*Mr. Bell*

407. Plant Anatomy (3) *Mr. Hillson*
409. Plant Ecology (3) *Mr. Kovar*
414. Taxonomy of Vascular Plants (3) *Mr. Wahl*
419. Mycology (3) *Mr. Fergus*
421. Botanical Technique (3) *Mr. Pursell*
422. (Zool. 422) Advanced Genetics (3) *Messrs. Wright and Grun*
424. (W.U. 424) Commercial Tropical Woods (3)

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Winter term. *Mr. Bell*

501. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years. *Mr. Fergus*

505. (Zool. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Bot. (Zool.) 405 or 422. Spring term, odd years. *Mr. Grun*

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Bot. 407. Spring term, even years. *Mr. Hillson*

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration, and catabolism. Prerequisite: Bot. 406. Fall term, odd years. *Mr. Hamilton*

512. Advanced Plant Physiology (3) Continuation of Bot. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Bot. 406. Winter term, even years. *Mr. Hamilton*

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Prerequisite: Bot. 409. Winter term, odd years. *Mr. Kovar*

518. Special Problems (1-12) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

521. Molds, Yeasts, and Actinomycetes (3) Morphology and taxonomy of fungi important in microbiology; identification and techniques of study. Fall term, odd years. *Mr. Fergus*

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Bot. 419. Winter term, even years. *Mr. Fergus*

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Bot. 419. Spring term, even years. *Mr. Fergus*

524. (Zool. 524) Seminar in Genetics (1 per term) *Messrs. Wright and Grun*

527a,b. Plant Biology for Teachers (3 each) (a) Structure and physiology; (b) reproduction processes, development and relationships of plant groups. Methods of obtaining materials and setting up experiments. Designed for teachers and prospective teachers. Prerequisite: general biology or general botany courses. Summer term only; a and b given in alternate years. Accepted by the Department of Botany only for the M.Ed. and D.Ed. degrees. *Mr. Westerfeld*

528. (Zool. 528) Population Genetics (3) Factors affecting gene frequency, genotype frequency, genotype-environmental interaction, and genetic relationship in natural and artificial populations. Winter term, even years.

533. (Zool. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

534. Morphology of Marine and Fresh-Water Nonvascular Plants (4) Classification, structure, development, and phylogenetic relationships of algae, liverworts, and mosses. Prerequisite: Bot. 421. Spring term, odd years. *Mr. Hillson*

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years. *Mr. Grove*

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seed and fruit development. Winter term, even years. *Mr. Grove*

537. (Sec.Ed. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

538. Botany Seminar (1 per term) Presentation and discussion of selected topics.

BUSINESS ADMINISTRATION

Fred W. Kniffin
In Charge of Graduate Programs in Business Administration
122 Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.
Graduate Faculty: Professors Bradley, Colwell, Cook, Day, Hexner, Kelley, Kniffin, McKinley, G. K. Nelson, Pashek, Richards, Saylor, Schrader, Strong, Waters, and Wherry; Associate Professors Babione, Beik, Carzo, Clewett, Ferrara, Greenlaw, Phalan, Sauerlender, Sussman, and Williams; Assistant Professor Decker.

The M.B.A. program is designed for those desiring professional training in business administration, regardless of their undergraduate background, in preparation for a career in either business or teaching. An applicant with little or no training in business administration may be admitted to the M.B.A. program and may schedule necessary preparatory courses while pursuing the graduate program. Three credits are required as preparatory courses in each of the following: accounting, business law, business statistics, economics, finance, management, and marketing.

The M.S. and Ph.D. degrees with a major in business administration are designed for those interested primarily in research and teaching.

For admission to these programs, a minimum of 18 acceptable undergraduate credits in the fields of accounting, commerce, economics, and business statistics—including at least 6 in economics and 3 in business statistics—is required. An applicant may be admitted with slight specific deficiencies which must be made up without degree credit.

Applicants for the various graduate programs in business administration are required to take the Admission Test for Graduate Study in Business given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. The test will be given at University Park and at numerous locations in most states and foreign countries in November,

February, April, and July. For dates and locations see the *Bulletin of Information,* Admission Test for Graduate Study in Business, published by the Educational Testing Service, 20 Nassau Street, Princeton, New Jersey. Applicants should read the bulletin carefully. All arrangements for taking the test must be made directly with the Educational Testing Service.

This graduate program has been accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Advanced Auditing (3-9)
404. Cost and Budgetary Control (3)
406. Advanced Federal Tax Accounting (3)
407. Contemporary Issues in Accounting (3)
408. Governmental Accounting (3)
409. Machine and Electronic Accounting Methods (3)

500. Accounting Seminar (3-6)

502. Managerial Accounting (3-6) Acounting techniques as control devices in business and industry; the use of quantitative data for policy decisions.

511. Interpretation of Account Data (3)

520. Problems in Accounting (3-6) Planned individual projects involving library, laboratory, or field work.

COMMERCE (COM)

406. Investment Valuation and Management (3)
408. Case Studies in Banking and Finance (3)
418. Estate Planning (3)
424. Marketing Research (3)
427. Retail Buying and Merchandising (3)
461. Regulation of Transport Carriers (3)
462. Problems in Trade and Transportation (3)
491. Urban Land Utilization (3)

500. Case Studies in Business Administration (3) Case studies of business and management policy with respect to procurement, production, selling, finance, accounting, relations with government, labor, and the public.

501. Commerce Seminar (3-6) Reports on research in selected fields of commercial activities.

502. Seminar in Business Management (3-6)

503. Transportation and Public Utility Seminar (3-6)

504. Problems in Commerce (3-6) Planned individual projects involving library, laboratory, or field work.

506. Seminar in Investments and Corporation Finance (3-6)

517. International Business Practices (3) Practices of exporters and importers dealing in commodities traded in world markets under competition, monopoly, or governmental control. Prerequisite: Com. 162.

523. Seminar in Marketing (3-6) Research in modern marketing trends.

525. Case Studies in Insurance (3-6) Analysis of management's insurance problems, such as the feasibility of self-insurance; proper allocation of insurance premiums and coverage in selected industries, etc. Prerequisites: Com. 180, 280.

536. Sales Management Seminar (3) Principles of sales planning and administration; coordination of selling with advertising, promotion, production, and accounting; use of market research selling costs and budgets.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administration.

MANAGEMENT (MGMT)

430. Administrative Management (3)
435. Cases in Public Relations (3)

BUSINESS EDUCATION

F. Wayne House
In Charge of Graduate Programs in Business Education
243 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

This program provides advanced preparation for teachers of business subjects for secondary schools and colleges. The subject-matter areas encompass secretarial, accounting, retailing, clerical, and general business sequences. The program may be adapted for the preparation of supervisors of business education.

A minimum of 18 acceptable undergraduate credits in education and psychology plus a minimum of 30 credits in business and business education subjects are required for admission.

All candidates specializing in business education are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanities.

The following courses in business education are described on page 166 under the heading Secondary Education: Sec.Ed. 456, 459, 460, 461, 462, 463, 466, 468, 511, 575, 576, 577, and 578.

CERAMIC TECHNOLOGY

Floyd A. Hummel, *Head of the Department*
214 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Buessem, Hummel, and Weyl; Associate Professors Rindone, Stubican, and Williamson; Assistant Professor McKinstry.

The background for admission is a bachelor's degree in ceramics or in one of the related physical sciences. A knowledge of differential and integral calculus is required together with adequate physics and chemistry.

In view of the wide field covered by ceramic technology, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass technology. This makes it easily possible for students whose major subject for the bachelor's or master's degree has been either phyics or chemistry to take appropriate graduate studies in ceramic technology.

Special facilities exist for research in the areas of clay mineralogy, phase equilibria, mineral synthesis, mechanical properties, ferrite and ferroelectric studies, glass technology, and high temperature reaction kinetics.

CERAMIC TECHNOLOGY (CER T)

400.	Crystal Chemistry of Ceramic Materials (2)	*Mr. Brindley*
402.	Principles of Ceramic Engineering (3)	*Mr. Williamson*
404.	Ceramic Seminar (1)	*Mr. Hummel*
405.	Ceramic Research and Design (1)	
406.	Rheology and Fluid Properties of Ceramic Systems (2)	*Mr. Williamson*
407.	Ceramic Materials Laboratory (2)	*Mr. Williamson*
408.	Heat Treatment of Ceramic Materials (1)	*Mr. Stubican*
409.	Heat Treatment Laboratory (2)	*Mr. Stubican*
410.	Phase Relations in Ceramic Systems (3)	*Mr. Hummel*
411.	Principles of Ceramic Processes (2)	*Mr. Buessem*
412.	Surface Chemistry of Ceramic Materials (1)	*Mr. Weyl*
414.	Principles of Ceramic Technology (2-3)	*Mr. Hummel*
415.	Principles of Glass Technology (3-4)	*Mr. Rindone*
420.	Refractories (2-3)	*Mr. Stubican*
425.	Ceramic Research and Design (2)	
430.	Electroceramics (2-3)	*Mr. Buessem*

500. Seminar in Ceramic Technology (1-2 per term) Current developments in ceramic technology and related fields. Required of all graduate students in ceramic technology. *Mr. Hummel and Staff*

501. Colloidal Behavior of Clays and Muds (2-4) Colloidal properties of ceramic clays, glazes, drilling muds, filtering and bleaching clays, and kindred systems. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Technology (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452.

506. Mechanical Properties of Ceramic Materials (2-3) Experimental stress-strain-time relations in elasticity, anelasticity, plasticity, and rupture; theory of strength and control. *Mr. Buessem*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Buessem*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. Chemical Aspects of the Constitution of Glass (1-3 per term) Historical development, properties, and atomistic interpretation of changes of properties with compositions, temperature, and past history. *Mr. Weyl*

512. Physical Aspects of the Constitution of Glass (1-3) Atomic structure of glass, its relation to physical properties; rheology; glass as a liquid. *Mr. Rindone*

515. Special Problems in Ceramic Technology (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Technology (1-3 per term) Intensive group study of special topics.

517. Research Instruments and Equipment (2) Applications of fundamental laws and principles in research instruments; care, adjustment, and effective use of instruments and equipment (demonstrations).

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Bates*

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in ceramic technology studies are listed under Mineral Sciences. The subject of color in glasses is treated in Min. 521.*

CHEMICAL ENGINEERING

Merrell R. Fenske, *Head of the Department*
131 Chemical Engineering Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Fenske, Quiggle, and Rose; Associate Professors Braun, Carnahan, Hersh, Jones, Klaus, and McCormick; Assistant Professor Lloyd.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, unit operations, unit processes, nuclear chemical engineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. The facilities for instruction and research in chemical engineering and petroleum chemistry include those of the Petroleum Refining Laboratory.

To be admitted, a student should be a graduate of an accredited curriculum in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science curriculums may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit.

Thesis research work in petroleum chemistry, for the M.S. and Ph.D. degrees in chemistry, may be done in the Department of Chemical Engineering.

CHEMICAL ENGINEERING (CH E)

404. Chemical Plant Design (3) *Messrs. Engel and Snyder*
405. Thermodynamics for Chemical Engineers (3) *Mr. Snyder*

406. Chemical Engineering Problems (3) *Messrs. Engel and Lloyd*
410. Chemical Engineering Principles (3) *Mr. Carnahan*
411. Chemical Engineering Principles (3) *Mr. Carnahan*
412. Chemical Engineering Principles (3) *Mr. Carnahan*
420. Cryogenic Engineering (3) *Mr. Fritz*
422. Petroleum Processes and Products (2)
430. Nuclear Chemical Engineering (3)
440. Chemical Engineering Materials (3) *Mr. Engel*
445. Chemical Engineering Research (1-5)
450. Process Dynamics (3) *Mr. Snyder*
460. Chemical Engineering (4)

500. Seminar in Chemical Engineering (1) Required of all graduate students.

505. Special Topics in Chemical Engineering (2-12) Intensive study in the various specialized fields of chemical engineering.

510. Advanced Heat Transfer I (3) Physical and chemical factors controlling the rate of heat transfer under conditions of steady flow.

511. Advanced Heat Transfer II (3) Flow of heat under varying temperature conditions.

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

516. Economic Balance (3) Problem work on the design of chemical engineering equipment from the economic standpoint.

518. Chemical Engineering Design (3) Complicated examples are discussed and worked out. Several different unit operations will be combined for the design of a complete installation.

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Mass Transfer (3) Problem course on developments in diffusion, fluid dynamics, and phase equilibrium.

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

530. Heat Transfer in Nuclear Reactors (3) Fluid flow, heat transfer, and design problems in nuclear reactor systems.

535. Applied Reaction Kinetics (3) Basic principles of chemical kinetics, simultaneous heat and mass transfer, and prediction of rates; their application to reactor design.

CHEMISTRY

Thomas Wartik, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S., M.Ed.
Graduate Faculty: Professors Aston, Brickwedde, Deno, Dixon, Fleming, Fritz, Hutchison, Jordan, Miller, Noll, Oakwood, Quiggle, Seward, Skell, Smith, Sommer,

Taft, Wartik, Willard, and Zook; Associate Professors Ascah, Goodman, Haas, Hayes, Hisatsune, Jones, Lampe, Schempf, Shamma, and Steele; Assistant Professors Adams, Bernheim, Gingerich, Haim, Lotz, Matwiyoff, Richey, Rosenblatt, and Schmulbach.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent and the computer, cryogenic, microscopy, petroleum, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at 1 p.m. at a departmental colloquium.

Students entering programs leading to the M.S. and Ph.D. degrees should have had training which includes at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is required, and a reading knowledge of at least one foreign language, preferably German, is expected.

The program leading to the M.Ed. degree is designed primarily for science teachers in secondary schools. Previous training should include a total of 18 credits in chemistry and 18 credits in education and related psychology.

Prior to scheduling their first term program, new students will take examinations in the four areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. Chemical Literature (1) — *Mrs. Strauss*
401. Seminar (1)
405. Nuclear and Radiochemistry (3)
410. Advanced Inorganic Chemistry (4)
*421-422. Analytical Chemistry (4 each)
426. Instrumental Methods of Analysis (3-5)
435. Organic Preparations and Laboratory Methods (3-5)
437. Qualitative Organic Analysis (3)
448. Colloid Chemistry (3)
*451-452. Physical Chemistry (3 each)
453. Advanced Physical Chemistry (3)
454. Advanced Physical Chemistry (3)
455. Physical Chemistry of High Polymers (3)
*457-458. Experimental Physical Chemistry (1 each)
459. Experimental Physical Chemistry (1)
470. Chemical Microscopy (3) — *Miss Willard*
471. Special Topics in Chemical Microscopy (2-6) — *Miss Willard*
472. Quantitative Organic Microanalysis (3) — *Mr. Fleming*
474. Quantitative Organic Microanalysis (3) — *Mr. Fleming*
477. Chemical Photomicrography (3) — *Miss Willard*
489. Introduction to Chemical Research (1-10)
†490. Organic Chemistry (5)
†491. Organic Chemistry (5)
†492. Advanced General Chemistry for Teachers (3)
†493. Selected Topics in Chemistry for Teachers (3)
†494. Chemical Demonstrations for Teachers (3)

500. Seminar in Inorganic Chemistry (1 per term)

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.
†Candidates for the M.Ed. degree.

501. Seminar in Physical Chemistry (1 per term)

502. Seminar in Organic Chemistry (1 per term)

503. Seminar in Analytical Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Separative and determinative processes in analytical chemistry.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12)

532. Organic Nitrogen Compounds (3) Chemistry, stereochemistry, and molecular structure of organic compounds containing nitrogen. *Mr. Aston*

534. Theoretical Organic Chemistry (3) Modern theories of structure; resonance; interpretation of physical properties; theory of rates; equilibrium properties. *Mr. Aston*

535-536. Organic Chemistry (3 each) Adapted to the needs of those doing research work in organic chemistry.

537. Organic Chemistry of High Polymers (3) High polymer theory and practice from the viewpoint of organic chemistry.

538. Organic Chemistry (3) Survey of organic chemistry arranged primarily for graduate students majoring in fields other than organic chemistry.

539. Stereochemistry (3) Comprehensive treatment of the principles of stereochemistry as applied to organic compounds. *Mr. Oakwood*

540. Experimental Methods of Physical Chemistry (3-5)

541. Phase Rule (3) The phase rule and its applications.

542. Colloids (3) The physics and chemistry of surfaces and their resulting colloid properties; methods of preparing colloids. *Mr. Smith*

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Chemical Thermodynamics and Introductory Statistical Mechanics (3) Continuation of Chem. 544 including the calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisite: Chem. 544.

546. Quantum Chemistry (3) Calculation of electronic properties of atoms and molecules by wave mechanical methods including molecular orbital theory. Prerequisite: Chem. 565.

547. Statistical Mechanics (3) Properties of matter at equilibrium, developed on the basis of energy levels of molecules and statistical mechanical theory. Prerequisite: Chem. 565.

548. Catalysis (3) Theory of catalysis and its application to industry.

560. Topics in Physical Chemistry (3-12)

561-562. Chemical Principles (3 each) Mathematical treatment of the classical principles of chemistry; their application to problems. Required of all graduate students. Prerequisites: Chem. 452, Math. 44, Phys. 204. A course in organic chemistry is recommended.

563. Chemical Kinetics (3) Theory and measurement of the rates of chemical reactions; the mechanism of chemical reactions.

564. Chemical Kinetics (3) Continuation of Chem. 563 including theory and measurement of photochemical reactions.

565. Atomic and Molecular Structure (3) Introduction to modern theoretical chemistry: chemical bonds and molecular spectra.

567. Advanced Theoretical Chemistry (3) Modern and current theories of the properties of chemical substances and their applications to chemical problems; the construction of chemical theory.

581. Experimental Methods in Petroleum Chemistry (1-12)

582. Topics in Petroleum Chemistry (2-6)

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS

Winona L. Morgan, *Head of the Department*
105E Home Economics South

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Britton, Harms, Morgan, Siegel, and Smith; Associate Professors Broderick and de Lissovoy.

Students may specialize in the guidance and development of children, relationships among various members of the family, problems of all stages of the family cycle, nursery school education, education for home and family living in the schools, parental education, and work with children and families in community agencies.

The entering student should have had at least 6 credits in the physical and biological sciences, 12 in the social sciences (which must include a basic course in sociology and one in psychology), and 6 in child development and family relationships. Students who are otherwise qualified but who lack some of these credits may be admitted and permitted to make up the deficiency credits along with a graduate program.

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CD FR)

418.	Family Relationships (3)	*Mr. Broderick*
429.	Advanced Child Development (3)	*Mr. de Lissovoy*
430.	Teaching in Nursery School (1-6)	*Miss Russell*
441.	Nursery School Organization (3)	*Miss Russell*
445.	(Psy. 445) Development Throughout Adulthood (3)	*Mr. Britton*
481.	Educational Methods with Preschool Children (3)	*Miss Russell*

500. Nonthesis Research (1-6)

508. Parental Education (3) Discussion and use of methods, experiences, and programs which can be used effectively to help parents in dealing with problems of parent-child relationships. *Miss Morgan*

515. The Teaching of Child Development and Family Relationships (3) Methods of selection and presentation of subject matter basic to understanding the development of children. *Miss Morgan*

529. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 credits in child development or 6 in educational or child psychology, plus 3 in statistics. *Miss Harms*

530. Problems in Child Development and Family Relationships (1-6) Problems involving individual research in library, laboratory, or field projects.

536. (Psy. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

545. The Family in Its Community (3) Cultural influences on family relationships; how the family orients its members to community living and group participation. *Mr. Broderick*

546. Seminar in Family Relationships (1-6) Reading, reports, and discussion of recent research in relationship aspects of family living; particular attention to studies of roles, crises, and adjustments within the family setting. *Mr. Broderick*

549. (Psy. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

CIVIL ENGINEERING

Benjamin A. Whisler, *Head of the Department*
212 Sackett Building

Degrees Conferred: Civil—Ph.D., M.S., M.Eng.
Graduate Faculty: Professors Kountz, Perez, Reen, Shulits, and Whisler; Associate Professors Barnoff, Blue, Gotolski, Nesbitt, and Underwood; Assistant Professor Larson.

The entering student should be a graduate in civil engineering from an accredited college of engineering. Students may specialize in structures, hydraulics, transportation engineering, surveying, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.
See also "Sanitary Engineering."

CIVIL ENGINEERING (C E)

400. Seminar (1-3)
401. Civil Engineering Projects (2-12)
412. Advanced Photogrammetry (3)
421. Highways and Streets (3)
423. Highway Safety and Traffic Control (3)
431. Civil Engineering Construction (3)
446. Advanced Soil Mechanics (3)
447. Advanced Structural Analysis (3)
448. Advanced Structural Design (3)

462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control (3)

500. Seminar in Civil Engineering (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

521. Transport Planning and Design (2-6) Planning and design of transportation facilities; basic principles and engineering techniques applied to airways, highways, pipe lines, railways, waterways.

522. Transport Operation and Maintenance (2-6) Engineering problems in operation, maintenance, and administration of airways, highways, pipe lines, railways, waterways. Prerequisite or concurrent: C.E. 51 or 421.

540. Advanced Structural Analysis (2-4) Geometry of flexure, deflections; analysis of continuous beams, rigid frames, arches; influence lines. Prerequisite: C.E. 46.

541. Advanced Structural Analysis (2-4) Truss deflection; trusses with redundant members, continuous trusses, framed arches; influence lines; secondary stresses; wind stresses; space framework; suspension bridges. Prerequisite: C.E. 46.

542. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports. Prerequisites: C.E. 412, 446.

543. Structural Engineering Projects (3-10) Investigation or design projects in concrete, soil mechanics, photoelasticity, analysis, etc. Prerequisite or concurrent: C.E. 447, 448.

544. Advanced Structural Design (2-4) Plain and reinforced concrete design as applied to buildings, bridges, retaining walls, domes, tanks, and dams; prestressed concrete. Prerequisite: C.E. 448.

545. Advanced Structural Design (2-4) Structural steel design as applied to riveted and welded girders, trusses, rigid frames, wind connections; timber design. Prerequisite: C.E. 41.

547. Advanced Structural Theory (3-6) Prestressed concrete, arches, suspension bridges, concrete dams, thin shells, and other current topics. Prerequisite: C.E. 447.

550. Engineering Construction (2-4) Construction methods applied to foundations, buildings, bridges, and other civil engineering construction work. Prerequisites: C.E. 41, 42.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fluids (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Advanced Problems in Sanitary Engineering (3-10) Investigations, analyses, and reports on current topics in sanitary engineering.

574. Analytical Evaluations in Sanitary Engineering (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Sewage Treatment Plant Design (1-6) Design of works for treatment of sewage or industrial wastes. Prerequisite: C.E. 71.

578. Industrial Hygiene (3) Principles of control of industrial toxics and the protection of the worker and the community.

579. Public Health Administration (3) Operation and duties of health departments at the various levels.

CLOTHING AND TEXTILES

Ruth W. Ayres, *Head of the Department*
120A Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professor Ayres; Associate Professors Densmore, Gates, and Tesi.

Work may be taken with major emphasis in the textile area, which stresses the background natural sciences, or in the clothing area, which stresses the background social sciences. Candidates are accepted who have a strong foundation and a good record in any of the following: home economics, chemistry, sociology, economics, or psychology.

CLOTHING AND TEXTILES (CL TX)

400.	Special Problems in Clothing and Textiles (1-6)	
402.	Fundamental Principles of Tailoring Construction (3)	*Mrs. Larson*
403.	Creative Pattern Making (3)	*Mrs. Larson*
404.	Draping (3)	*Mrs. Larson*
406.	Fashion Promotion (3)	
407.	The Textile and Clothing Industry (3)	*Mr. Tesi*
408.	Intermediate Textiles (3)	*Miss Densmore*
410.	Clothing for the Family (3)	*Mrs. Adams*
411.	Advanced Clothing Construction (3)	*Mrs. Larson*

500. Nonthesis Research (1-6)

501. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

503. Advanced Pattern Development (3) Analysis of advanced pattern designing principles to give students facility in original designing.

504. Advanced Draping (3) Analysis of principles and techniques as a basis for creation of original designs; survey of literature in dress design.

505. Clothing Instructional Materials (3) Development of instructional materials and techniques based on needs of diverse groups.

506. Clothing Behavior (3) Analysis and interpretation of clothing behavior through the application of theories selected from the behavioral sciences. *Miss Gates*

507. Problems in Relation to Clothing Consumption (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries. *Mr. Tesi*

508. Special Problems in Clothing and Textiles (1-6) Individual directed study, investigation, and practice in selected phases of textiles and clothing.

509. Seminar in Clothing and Textiles (1-6)

510. Research Methods and Evaluation in Clothing and Textiles (1-6) *Misses Densmore and Gates*

511. Current Developments in Clothing and Textiles (1-6) *Miss Ayres*

512. History of Clothing and Clothing Construction (3) *Miss Gates*

513. Advanced Textile Technology (6) *Miss Densmore*

COMPARATIVE LITERATURE

Philip A. Shelley
Chairman of the Committee on Comparative Literature
229 Sparks Building

Degrees Conferred: Ph.D., M.A.

Programs are arranged through a meaningful selection of courses offered by the several departments of languages and literatures, both ancient and modern, as well as of those specifically in the category of comparative literature. More than a minimum knowledge of foreign languages is required.

A thesis is required of all M.A. candidates in this major.

COMPARATIVE LITERATURE (C LIT)

400. Comparative Method in Literary Studies (3) *Miss Lüders*
443. (Ger. 443) Literary Relations of Germany with England and America (3-9) *Mr. Shelley*
470. Old Masters of the Modern Novel (3) *Mr. Morse*
480. Introduction to Folklore (3) *Mr. Bayard*

500. Seminar in Comparative Literature (3-6)

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to backgrounds, development, themes, and characteristics. *Mr. Bayard*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. Morse*

COUNSELING IN EDUCATION

George R. Hudson
In Charge of Graduate Programs in Counseling in Education
422 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professor Wellington; Associate Professor Hudson; Assistant Professor Hylbert.

Professional preparation programs are offered at the master's level for elementary or secondary school counselors, home and school visitors, college counselors, and rehabilitation counselors. Doctoral programs prepare for pupil personnel administration, college student personnel administration, or supervision of rehabilitation.

All candidates for graduate degrees in counseling in education must present for admission at least 27 undergraduate credits in economics, education, psychology, sociology, and physiology or anatomy, with some credits in at least three of these areas.

Prospective school counselors and home and school visitors must have a teaching certificate to enter the program and must have two years of teaching experience before receiving a degree. Those wishing to become college counselors must have a year of college teaching or college personnel experience to qualify for a degree. Since graduate students in rehabilitation counseling combine a supervised internship with professional training, their master's degree program is correspondingly lengthened.

A candidate for either a Ph.D. or a D.Ed. degree in counseling in education must spend at least three consecutive terms in residence after earning the master's degree. Students may be employed during this required residence period not to exceed one-half-time, thereby necessitating an extension of their residence requirements accordingly.

The following courses are used in the graduate programs of majors in counseling in education: Ed.Psy. 414, 490, 494, 502; Ed.Ser. 403, 404, 408, 409, 503, 505, 506, 507, 508, 509, 511, 512, 513, 522, 545, 551, 598, 600 or 610; Psy. 418, 426, 436, 437, Psy. (C.D.F.R.) 445, Psy. (Ed.Psy.) 450, Psy. 482, 535; Pl.Sc. 433; Soc. 403, 426, 427, 450; Anthy. 402; Econ. 404.

DAIRY SCIENCE

Donald V. Josephson, *Head of the Department*
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Almquist, Josephson, and Patton; Associate Professors Flipse, Keeney, Kesler, Nichols, and Watrous; Assistant Professor McCarthy.

DAIRY SCIENCE

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipide metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in agricultural and biological chemistry, bacteriology, zoology, or agricultural economics.

Prerequisite to graduate work is the completion of an undergraduate curriculum in dairy science or a related science area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

DAIRY SCIENCE (D SC)

418. Dairy Survey (1) *Mr. Josephson*
421. Technical Control Problems (1-10) *Messrs. Watrous and Keeney*
427. Milk Secretion (3) *Mr. Kesler*
428. Dairy Production Problems (1-6) *Mr. Kesler and Staff*
431. Physiology of Reproduction in Farm Animals (3) *Mr. Almquist*

501. Butter and Cheese (1-6) Manufacture and handling of butter and cheese. Prerequisites: D.Sc. 10, 23, Bact. 8, Bioch. 404. *Mr. Watrous*

502. Condensed Milk and Milk Powder (1-6) Condensing and drying of milk. Prerequisites: D.Sc. 10, 26, Bact. 8, Bioch. 404. *Mr. Keeney*

503. Public Milk Problems (1-6) Handling milk in modern plants. Prerequisites: D.Sc. 11, Bact. 8, Bioch. 404. *Mr. Watrous*

504. Ice Cream Manufacture (1-6) Manufacture of ice cream, ices, and other frozen milk products. Prerequisites: D.Sc. 11, Bact. 8, Bioch. 404. *Mr. Keeney*

505. Dairy Plant Economics (1-6) Economic factors involved in creamery operation and management. Prerequisites: D.Sc. 7, 11. *Mr. Watrous*

507. Dairy Cattle Management (1-6) Management of dairy cattle. Prerequisite: D.Sc. 27. *Mr. Kesler and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

509. Testing Dairy Products (1-6) Constituents of dairy products. Prerequisites: D.Sc. 11, Bact. 8, Bioch. 404.

510. Dairy Cattle Feeding (1-6) Application of fundamental research in animal nutrition to the feeding of dairy cattle. Prerequisites: D.Sc. 1, 29. *Mr. Kesler*

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: D.Sc. 322, Zool. 422, 3 credits in statistics. *Mr. Nichols*

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Mr. Josephson and Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. Flipse*

522. Research Procedures in Dairy Technology (3) Research problems and methods in dairy technology with major emphasis on dairy chemistry. Prerequisite: Bioch. 404. *Mr. Patton*

EARTH SCIENCES

Hans Neuberger
Chairman of the Committee on Earth Sciences
323 Mineral Industries Building

Degree Conferred: M.Ed.

This program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, meteorology, mineralogy, and soils.

The program prepares candidates to teach at least one field of the earth sciences, familiarizes them with at least two additional earth science subjects, and at the same time enables them to increase their competence in the physical sciences, the biological sciences, and mathematics.

The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

ECONOMICS

Grant N. Farr, *Head of the Department*
124 Boucke Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Budd, Hench, Hexner, Kaufman, Mares, Mason, Newman, Reede, Saylor, and Stout; Associate Professors Iwand, Klein, Myers, Prybyla, Robinson, and Sauerlender.

Opportunities are available for concentration in business statistics, economic theory, labor, international economics, government economic policy, money, credit, and public finance.

A thesis is required of all M.A. candidates in this major.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics.

BUSINESS STATISTICS (B S)

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)
404. Current Economic Issues (3)
405. Advanced Economic Analysis (3)
406. Economic Growth: Underdeveloped Areas (3)
412. Economics of Collective Bargaining (3)
415. Social Insurance (3)
418. Economics of Wages and Employment (3)
419. Case Studies in Labor-Management Relations (3)
423. State and Local Taxation (3)
425. The Money Markets (3)
428. Income and Employment Theory (3)
433. International Monetary Economics (3)
442. Monopoly, Competition, and Their Regulation (3)
450. The Business Cycle (3)
451. Advanced Money, Banking, and Fiscal Policy (3)
480. Mathematical Economics (3)
490. Measurement of the Economy (3)
491. Analysis of Linear Economic Models (3)
499. Foreign Study in Economics (2-6)

500. Economics Seminar (3-6)

501. Research Methods in Economics (3-6)

506. Problems in Economics (3-6) Planned individual projects involving library, laboratory, or field work.

507. Seminar in International Economics: Theory and Policy (3-6)

508. Seminar in Money, Credit, and Public Finance (3-6)

510. Econometrics (3) Statistical estimation in mathematically formulated economic relationships.

511. Seminar in Industrial Disputes (3)

512. Wages (3)

513. Development of Economic Doctrines (3-6)

515. Labor Seminar (3)

522. Advanced Economic Theory (3-6) Theory of price and income determination.

EDUCATIONAL ADMINISTRATION

Walter J. DeLacy
In Charge of Graduate Programs in Educational Administration
156 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Davison, DeLacy, McAulay, McGarey, Miller, and Remaley; Associate Professors Bosch and Willower.

Professional preparation programs are offered at the master's level for elementary and secondary school principals and supervisors. Doctoral programs prepare for positions of supervising principal, assistant superintendent, and superintendent of schools.

Requirements for admission to a graduate program in educational administration include 18 approved undergraduate credits in education and psychology. Applicants for admission to the master's degree program are required to have had one year of teaching experience, or to be currently engaged in teaching. Two years of teaching experience are required for admission to the doctoral program.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600 or 610 thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term, unless approved by the candidate's committee, shall be considered automatic withdrawal.

Although candidates are required to specialize in a field of professional education, they are also encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

Courses in educational administration (Ed.Ser. 480 and 565 to 582 inclusive) are listed under the offerings of the Department of Educational Services. Additional courses may be selected from other areas and departments to meet the student's needs, including certification requirements.

DEPARTMENT OF EDUCATIONAL SERVICES—This department (Franklin A. Miller, *Head*) offers graduate programs in counseling in education, educational administration, and higher education. It also offers the following course sequences which are not graduate majors:

Adult Education	460
History and Philosophy of Education	415-420, 516-523
Research, Seminars, and Projects	596-599
Safety Education	450-452
Special Education	425-431, 525-529

These courses carry graduate credit and, with the approval of the student's adviser, may be applied toward the requirements for an advanced degree in any major field.

EDUCATIONAL SERVICES (ED SER)

403. Guidance Principles and Practices (3)
404. Teaching and Group Guidance About Occupations (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
415. Character Education (2-3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
420. History of Modern European Education (3)
425. Education of Exceptional Children (2-3)
427. Education of the Mentally Retarded (2-3)
429. Education of the Mentally Gifted Child (1-3)
430. Practicum in the Education of Atypical Children (1-8)
431. Atypical Children and Educational Adjustments (3)
450. Visual and Other Aids in Safety Education (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals.

505. Occupational and Educational Information (3) Occupational information for guidance purposes; educational information related to vocational choice and preparation. Prerequisite: Ed.Ser. 403.

506. Student Analysis Procedures for Counselors (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing.

507. Supervised Experience in Student Counseling (3) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Ed.Ser. 403.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Ed.Ser. 403.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Ed.Ser. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Ed.Ser. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisite: Ed.Ser. 511.

513. Supervision of Guidance Workers (3) Practical experience in supervising and evaluating work of counselors. Prerequisite: Ed.Ser. 507.

516. Social Foundations of Education (2-4) Social institutions and functions and their relationship to public education; analysis of the functions assignable to formal education. Prerequisites: El.Ed. 311 or Sec.Ed. 331; Ed.Psy. 14.

517. Advanced Philosophy of Education (2-4) Analysis of educational policy and practice for philosophic consistency and commitment; philosophical implication in selected educational literature.

518. Evolution of Educational Thought (2-3) Rise of formal educational philosophy from Plato to John Dewey; preliminary reference to Chinese, Hindu, Chaldean, Persian, Hebrew, and Egyptian theories.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina.

522. Comparative European Education (3) Educational policies and practices in school systems in western and central European nations. Prerequisite: Ed.Psy. 14.

523. Education in Russia, Asia, and the Middle East (2-3) Current educational activities in Soviet Russia and other eastern European countries; the Middle East, North Africa, and the Far East.

525. Internship in Special Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

527. Problems in the Education of the Mentally Retarded (1-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience; Ed.Ser. 425 or 577, and Ed.Ser. 427.

529. Problems in the Education of the Mentally Gifted (1-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience; Ed.Ser. 425 or 577, and Ed.Ser. 429.

545. Higher Education in the United States (2-3) Historical perspective and current status; development of functions and structures; issues in curriculum, admissions, government, administration, and finance.

546. The Principles of College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in College Teaching (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professional Education of Teachers (3) Development and present status of teacher education; objectives and standards; selection and guidance of students; personnel problems in relation to staff. Prerequisite: 6 credits in advanced courses in education and a course in educational psychology.

551. Student Personnel Programs at the College Level (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

555. Seminar in Collegiate Education (1-6) Special topics in higher education. Prerequisite: courses or experience in higher education.

565. Principles of School Supervision (2-3) Organization of supervision; planning the supervisory program; developing standards of teaching and learning; improvement of learning through tests and teacher rating. Prerequisites: 18 credits in education and 3 years' teaching experience.

566. The Elementary School Principal as Supervisor (2-3)

567. The Secondary School Principal as Supervisor (2-3) Improvement of instruction; improvement of teachers in service; evaluation of teaching procedures; methods of supervision; selection and use of textbooks. Prerequisite: three years' teaching experience.

568. The Elementary School Principal as Administrator (2-3) Duties of the elementary school principal in organizing and administering his school.

569. The Secondary School Principal as Administrator (2-4) Problems of

schedule making, teachers' meetings, curriculum making and revision, organization of extracurricular and guidance programs. Prerequisite: teaching experience.

570. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) Utilization of public participation in the formulation of school policies; relation of the school staff to the public and techniques for informing the public about what schools can do. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

574. State and National Education Programs (2-3) Existing state and federal functions and relations to education; proposed programs. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes; torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

577. The Administration of Public School Education for Atypical Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Factors which make for the improvement of public schools; influences with which administrators may work to improve the schools in their local situations; subjection of data on individual administrative situations to scientific check. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience; Ed.Ser. 573.

580. Seminar in School Administration (1-6) Efficiency in supervision, methods of diagnosis and evaluation of teaching and learning procedure, improving instruction, maintaining teacher morale, stimulating cooperative work. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

581. Educational Survey Techniques (2-3) Methods for appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

596. Seminar in Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Education (1-6) Independent work in the study of topics in education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

599. Internship in Public School Research (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

ELECTRICAL ENGINEERING

Arthur H. Waynick, *Head of the Department*
105 Electrical Engineering Building

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus)
Graduate Faculty: Professors Holt, Ross, Tarpley, Volz, and Waynick; Associate Professors Atwater, Ferraro, Marsh, Nisbet, Schmerling, and Shields.

Course offerings and research facilities are available in the following areas: information theory, microwave theory and techniques, networks, computers (including digital, analog, and network analyzer), control, power conversion, servomechanisms, tubes and transistors, dynamical machine analysis, power dispatching, relay protection, and wave propagation.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate course work in electrical circuits, machinery, and electronics.

ELECTRICAL ENGINEERING (E E)

421a,b,c,d. Electrical Engineering Problems (2-12)
425. Symmetrical Components (3)
426. Transistors (3)
428. Servomechanisms (3)
432. Microwave Methods and Analysis (3)

435. Engineering Analysis (3)
438. Electromagnetic Theory and Radiating Systems (3)
439. Pulse Techniques (3)
441. Active Circuits (3)
450. Electrical Network Theory (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Digital Computers (3)

520. Seminar (1) Required of all graduate students in electrical engineering. Conferences, reading, and presentation of technical papers.

521. Advanced Electrical Engineering Problems (2-12)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

528. Servomechanisms (3) Advanced treatment of transient and steady-state behavior of closed-cycle control systems with special attention to stability and design of stabilizing controllers. Prerequisite: E.E. 428.

532. Ultra-High-Frequency Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisite: E.E. 432 or 438.

535. Engineering Analysis (3) Engineering applications of complex variables, conformal mapping methods, and potential plotting; Laplace transform methods and stability criteria. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electrical and magnetic fields, using the Maxwell-Lorentz equations as applied to vector fields and special solutions for antennae, wave guides, and other engineering applications. Prerequisite: E.E. 438.

550. Passive Network Synthesis (3) Network synthesis using (a) realizability conditions; (b) image parameters, realization methods for two-terminal pair networks; rational fraction approximations; time domain synthesis. Prerequisite: E.E. 450.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 43 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ELEMENTARY EDUCATION

A. Madison Brewer, *Head of the Department*
150 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Bixby, Brewer, McAulay, Murphy, and Russell; Associate Professors Alessandro, Alfke, Bosch, Corle, Veatch, and Zaffaroni; Assistant Professor Riedesel.

The graduate programs provide advanced professional preparation for kindergarten teachers, elementary school teachers, and curriculum specialists. For admission 18 credits in elementary education, including teaching experience, are required.

ELEMENTARY EDUCATION (EL ED)

401. Training in Nature for Camp Counselors (3)
426. Problems of Elementary School Arithmetic (2-3)
433. Teaching Social Studies in the Elementary Grades (2-3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (2-3)
444. Reading Disabilities (2-3)
445. (Sec.Ed. 445) Techniques in Remedial Reading (2-6)
449. Teaching Children's Literature (2-3)
453. Special Problems in the Teaching of Elementary School English (2-3)
461. Elementary Education (2-3)
467. Advanced Theory of Kindergarten (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

546. (Sec.Ed. 546) Seminar on Reading Instruction (3-6) Research, procedures, and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: El.Ed. 443 or Sec.Ed. 443.

556. (Sec.Ed. 556) Reading Clinic Practice: Analysis of Reading Disabilities (3-6) Analysis of extreme reading disabilities and recommended remedial procedures; experience in preparation of case reports. Prerequisites: El.Ed. 444, El.Ed. (Sec.Ed.) 445.

557. Reading Clinic Practice: Remedial Procedures (1-9) Practicum in special classes for reading disabilities; corrective and remedial procedures; specific

procedures for correction of various types of reading disabilities. Prerequisite: El. Ed. 444 or El.Ed. (Sec.Ed.) 556.

559. Reading Clinic Research (1-15) Prerequisites: El.Ed. 443 or Sec.Ed. 443; El.Ed. 444.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisite: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers, administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

594. Seminar in Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

ENGINEERING MECHANICS

Joseph Marin, *Head of the Department*
105 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.
Graduate Faculty: Professors Davids, Hardenbergh, Hu, Marin, Vierck, and Wislicenus; Associate Professors Jaunzemis and Neubert; Assistant Professor Sharma.

Graduate study is available in mechanical behavior of solids, analytical methods in mechanics, experimental methods in mechanics, mechanics of rigid bodies, mechanics of deformable bodies, and fluid mechanics.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics.

ENGINEERING MECHANICS (E MCH)

400. Advanced Strength of Materials (3) *Mr. Sharma*
401. Elements of Vibrations (3) *Messrs. Neubert and Vierck*
402. Applied and Experimental Stress Analysis (3)
403. Mechanics of the Solid State (4) *Mr. Hu*
404. Research in Engineering Mechanics (1-6)

407. Numerical Methods of Analysis (3) *Mr. Vierck*
408. Elasticity and Engineering Applications (3) *Mr. Sharma*
409. Advanced Mechanics (3) *Mr. Hardenbergh*
410. Mechanics of Space Flight (3)
412. Experimental Methods in Vibrations (3) *Mr. Neubert*
413. Plastic Analysis of Structures (3) *Mr. Hu*
414. Elements of Material Science (3)
421. Continuum Mechanics (3) *Mr. Jaunzemis*
422. Continuum Mechanics (3) *Mr. Jaunzemis*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13. *Mr. Marin*

504. Applied Elasticity (3) Analyses of stress and strain in two dimensions; problems in elasticity and elastic stability; emphasis on applications to machine and structural design. Prerequisite: E.Mch. 13.

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507.

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Mr. Hu*

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to internal pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13.

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13.

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics.

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potentials; applications. Prerequisite: E.Mch. 540. *Mr. Jaunzemis*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 44 or 431. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisite: E.Mch. 13, Math. 44 or 431. *Mr. Vierck*

523. Relaxation Methods (3) Relaxation methods compared to iteration and other numerical methods of analysis; application to elasticity, plasticity, stability, fluid flow, heat transfer, and related fields. Prerequisites: E.Mch. 13 or 111, Math. 44. *Mr. Vierck*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: Math. 451 or E.E. 435 or M.E. 452. *Mr. Davids*

Unit A (3) Basic concepts of tensors; matrices; numerical procedures; approximation; Fourier, Legendre, and other orthogonal series; applications; Bessel and other special functions.

Unit B (3) Basic solutions of Laplace, diffusion, wave equations; boundary-value problems; Fourier, Laplace transforms; contour integration techniques; Caignard's, energy methods.

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical applications. Prerequisite: E.Mch. 522. *Mr. Davids*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, vibration techniques in nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*

529. Engineering Applications of Sonics (3) Sound and ultra sound in engineering and science; principles, radiation, transducers, devices for sonic processing and testing. Prerequisite: Phys. 443.

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14. *Mr. Marin*

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 504 or 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507.

540. Mechanics of Continua (3) Unified treatment of the theories of continuum mechanics: tensor analysis and kinematics of material media, dynamics, irreversible thermodynamics, constitutive equations. *Mr. Jaunzemis*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

ENGLISH

Henry W. Sams, *Head of the Department*
245 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Bayard, Brady, Condee, Cramer, Davis, Euwema, Frank, Lewis, Major, Morse, Peck, Rubin, Sams, Sutherland, and Young; Associate Professors Austin, Bressler, Jewkes, Meserole, Oldsey, Reed, G. Smith, and Weintraub; Assistant Professors Borklund and Hansen.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work.

A thesis is required of all M.A. candidates in this major.

ENGLISH (ENGL)

408. Advanced College Grammar (3) — *Miss McElwee*
412. The Writing of Fiction (3-6) — *Messrs. Rubinstein and Barth*
414. Biographical Writing (3) — *Mr. Weintraub*
422. Masters of British Literature (3-6)
423. History of British Literature (3) — *Messrs. Major and Steese*
432. Masters of American Literature (3-6) — *Messrs. Bressler, Davis, and Staff*
433. History of American Literature (3) — *Messrs. Sutherland and Gidez*
434. Movements in American Literature (3-6) — *Messrs. Hansen, Meserole, and Staff*
437. American Poetry (3) — *Messrs. Rubin and Hansen*
438. American Drama (3)
445. Chaucer (3) — *Mr. Frank*
447. British Poetry from Skelton to Dryden (3) — *Messrs. Reed and Smith*
448. English Drama Before Shakespeare (3) — *Mr. Jewkes*
449. Shakespeare: the Chronicle and Problem Plays (3) — *Messrs. Reed and Smith*
451. Prose and Poetry of 18th Century England (3) — *Mr. Sams*
455. The Novel in England to Charles Dickens (3) — *Mr. Brady*
458. The Drama from Dryden to Sheridan (3) — *Mr. Rogers*
461. British Prose of the 19th Century (3) — *Mr. Cramer and Miss Austin*
462. Wordsworth and Coleridge (3) — *Mr. Cramer and Miss Austin*
463. Byron, Shelley, and Keats (3) — *Mr. Peck*
465. Victorian Novel (3) — *Miss Austin*
466. The American Novel to 1900 (3) — *Messrs. Young and Oldsey*
467. Victorian Poetry (3) — *Mr. Cramer*
470. Literature of the British Commonwealth (3) — *Mr. Sutherland*
475. Modern British Fiction (3) — *Messrs. Sutherland and Weintraub*
476. The American Novel Since 1900 (3) — *Messrs. Young and Lewis*
477. British and American Poetry of the 20th Century (3)
478. British and Irish Drama Since 1890 (3) — *Mr. Weintraub*
481. History of English Literary Criticism (3) — *Messrs. Sams, Bressler, and Borklund*
488. Modern Continental Drama (3)
491. Literature for Teachers in Secondary Schools (3) — *Mr. Bressler*
*499. English Institute (6-12) — *Mr. Bowman*

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. — *Messrs. Smith and Meserole*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. — *Mr. Jewkes*

522. Old English Literature (3) A reading of the more important poetic works in Old English. — *Mr. Jewkes*

*A maximum of 6 credits in one summer.

540. Studies in Literature of the Renaissance (3-6) *Messrs. Reed and Smith*

541. Medieval Studies (3) Seminar in special problems in medieval English literature. *Mr. Frank*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer. *Mr. Frank*

543. Studies in 17th Century Literature (3-6) Topics will be drawn from any or all aspects of 17th century literature. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700. *Mr. Brady*

545. Chaucer (3) A critical study of the principal works of Chaucer; emphasis on literary backgrounds and exegesis. *Mr. Frank*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Shakespeare's Contemporaries and Immediate Successors in Drama (3) *Mr. Jewkes*

549. Shakespeare (3) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Messrs. Reed and G. Smith*

552. The Age of Swift (3) Special studies varying from year to year. *Mr. Sams*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Brady*

554. Studies in American Literature to 1812 (3) *Messrs. Meserole and Hansen*

561. Studies in the Romantic Movement (3-6) *Messrs. Peck and Cramer*

562. Studies in the Literature of Victorian England (3-6) *Mr. Cramer and Miss Austin*

564. Studies in American Literature, 1812 to 1900 (3) The major figures treated will vary from year to year. *Messrs. Rubin, Davis, and Oldsey*

573. Studies in Contemporary Literature (3-6) *Messrs. Morse and Weintraub*

574. Studies in American Literature Since 1900 (3) *Messrs. Young and Lewis*

581. Contemporary Literary Criticism (3) *Mr. Sams*

590. Research Problems in English (3-6) Methods of research in English, problems of bibliography, and method of evaluating sources and materials.

591. Problems in American Literary Study (3-6) *Messrs. Bressler, Davis, and Oldsey*

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early 16th century to the present. *Mr. Bayard*

595. Studies in British Fiction (3) *Messrs. Sutherland and Peck*

596. Studies in American Fiction (3) *Messrs. Lewis and Young*

597. Studies in American Poetry (3) *Messrs. Rubin, Davis, and Hansen*

ENTOMOLOGY

Beckford F. Coon
Acting Head of the Department of Agricultural Entomology
212 Frear Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors E. J. Anderson, Cheng, and Coon; Associate Professors Boyle and Rutschky; Assistant Professors Smyth and Snetsinger.

A student majoring in entomology may specialize in apiculture, ecology, economic entomology, morphology, physiology, insect resistances of plants, taxonomy, or toxicology of insecticides.

For admission a student is required to have 24 credits in entomology or zoology and related biological sciences; and he should have had chemistry through organic chemistry. Courses in physics and mathematics are also advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3)
403. (Zool. 403) Systematics (3) *Mr. Boyle*
405. Insect Morphology (3) *Mr. Rutschky*
413. Entomology Seminar (1 per term)
429. Principles of Insect Control (3)
431. Entomological Problems (1-6)

505. Advanced Morphology of Insects (3) Advanced work in either external or internal morphology of insects. *Mr. Rutschky*

506. Immature Insects (3) The morphology and taxonomy of the immature stages of insects. Spring term, even years.

508. The Biological Control of Insects (2) Artificial use of bacteria, fungous diseases, and animals in control of injurious insects; methods and equipment for rearing parasites and predators on a large scale.

509. Entomological Technique (2) Methods of collecting, rearing, preparing, and preserving insects in all stages, keeping records, and preparing illustrations. Fall term, odd years. *Mr. Coon*

514. Advanced Systematic Entomology (1-10 per term) Taxonomy of various orders of insects selected to meet the needs of the individual student. *Mr. Boyle*

520. Special Topics (1-6)

528. Insect Physiology (4) Normal functions of the insect body. Fall term, even years. *Mr. Smyth*

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years. *Mr. Smyth*

540. Insect Resistance in Plants (2) Mechanism, expression, permanence, and measurement of resistance to insects with special reference to farm crops. Spring term, odd years. *Mr. Coon*

EXTENSION EDUCATION

Emory J. Brown
Chairman of the Committee on Extension Education
205 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competencies which enable them to become more effective professional workers. Options have been developed for the Colleges of Agriculture and Home Economics. Additional options will be offered as they are developed by other Colleges.

Entrance requirements for an M.Ed. in this major include a minimum of 18 credits in education and 12 in the social sciences and a strong background in agriculture or home economics. Entrance requirements for the M.Agr. degree include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

FAMILY ECONOMICS AND HOME MANAGEMENT

Marjorie M. Knoll
Head of the Department of Home Management, Housing, and Home Art
271 Home Economics South

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Harms, Hotchkiss, Knoll, and Wiesendanger; Associate Professor Smith.

Those interested in emphasizing a study of home management, family economics, family housing, and home equipment may do so through this major. There are no specific course requirements for admission.

In the graduate program family management practices, their effects upon members of the family unit, and the interaction of such practices with the local and national economy are studied in relation to principles of economics, philosophy, psychology, sociology, and political science.

CONSUMER SERVICE AND EQUIPMENT (CS EQ)

403. Lecture-Demonstration Techniques (3)
413. Home Equipment (3)
450. Problems in Household Equipment (1-6)

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

415. Household Buying Practices (3)
419. Managing Family Financial Resources (3)
424. Economic Conditions in Relation to the Family (3)

439. Management Principles in Home Operation (2)
442. Resident Experience in Home Management (3) Room and board will be charged at regular rates. *Miss Chennault*
445. Home Management Experience (3) *Miss Chennault*
477. Family Management (3)

500. Nonthesis Research (1-6) Nonthesis research problems.

515. Consumer Problems (2-3) Methods of securing, evaluating, and presenting data concerning household commodities. For home economics teachers in high schools, colleges, and adult classes. Prerequisites: F.E.H.M. 442, F.N. 220.

524. Economic Problems of the Household (3) Economic problems of the present-day family; special emphasis on factors in household production, use of money income, and standards of living. Prerequisites: Econ. 14, F.E.H.M. 439.

528. Home Management Supervision (2-3) Evaluation of objectives and techniques in organization, supervision, and teaching of the home management house experience. Prerequisite: F.E.H.M. 439.

543. Home Management in Relation to Family Living (3) Includes work with families in solution of their management problems. Prerequisites: F.E.H.M. 439, F.N. 220.

544. Problems in Family Economics and Home Management (1-6) Investigation of selected problems in family economics and home management. Prerequisite: 6 credits of family economics or home management courses in home economics.

550. Seminar in Family Economics and Home Management (1-6) Discussion and reports on developments in family economics and home management.

FOOD SERVICE AND HOUSING ADMINISTRATION

S. Earl Thompson
Head of the Department of Hotel and Institution Administration
4A Home Economics Building

Degrees Conferred: M.S., M.Ed.

Graduate work in this field trains for management positions in institutions which provide food service and housing to large groups, such as hospitals, residence halls, children's homes, and other public and private organizations. For admission, a student should have a baccalaureate degree in this or a related field.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (2)
410. Advanced Quantity Food Production (3)
425. Food and Labor Management and Control (3)
461. Institution Administration (3)
470. Problems in Food Service and Housing Administration (3)

502. Problems in Institution Administration (3-6) Individual study of problems in institution administration. Prerequisites: F.S.H.A. 310, 330.

FOODS AND NUTRITION

GEORGE P. BARRON, *Head of the Department*
202B Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., and M.Ed. in Foods and Nutrition; M.S. in Nutrition in Public Health.
Graduate Faculty: Professors Barron, Dodds, Gordon, and Pike; Associate Professor Olson.

Graduate programs in foods and nutrition prepare students for careers in college teaching, research, and adult program leadership. The program in nutrition in public health prepares the student for work in public health agencies.

For admission to a graduate program in foods and nutrition, a student must have completed at least 9 credits in organic and inorganic chemistry, 3 in biological chemistry, 3 in bacteriology, 3 in physiology, 4 in other physical and biological sciences, and 8 in foods and nutrition.

For admission to the program in nutrition in public health, the requirements are at least 9 credits in organic and inorganic chemistry, 3 in biological chemistry, 3 in bacteriology, 12 in social sciences, 7 in foods, and 4 in nutrition.

FOODS AND NUTRITION (F N)

400. SPECIAL PROBLEMS IN FOODS AND NUTRITION (1-3)
420. EXPERIMENTAL COOKERY (1-6) *Miss Olson*
421. CULTURAL AND AESTHETIC ASPECTS OF FOOD (3) *Mrs. Jennings*
422. SCIENTIFIC PRINCIPLES OF FOOD PREPARATION (3) *Miss Gordon*
426. RECENT DEVELOPMENTS IN FOODS (3)
452. NUTRITIONAL ASPECTS OF DISEASE (3) *Miss Pike*
456. NUTRITION IN THE COMMUNITY (3)
457. PRINCIPLES OF NUTRITION (3)
458. APPLIED NUTRITION (2)
459. ADVANCED NUTRITION (3)
490. FOODS AND NUTRITION SEMINAR (1)

520. READINGS IN FOODS (2) Critical review and reports of literature on selected food topics. *Miss Gordon*

521. SEMINAR IN FOODS (1-6) Discussion and reports on current research in the foods field. Prerequisite or concurrent: F.N. 520. *Miss Gordon*

522. ADVANCED EXPERIMENTAL FOODS (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation. *Miss Gordon*

530. PROBLEMS IN FOODS AND NUTRITION (1-6)

531. ADVANCES IN FOODS AND NUTRITION (3) Recent findings in the related areas of foods and nutrition.

550. READINGS IN NUTRITION (3) Readings and reports of selected topics in nutrition. Prerequisite: F.N. 457.

551. SEMINAR IN NUTRITION (1-6) Selected topics and recent advances in nutrition.

552. NUTRITION IN DISEASE (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy. *Miss Pike*

553. Nutrition of Children (3) Nutritional needs of the normal child during prenatal life, infancy, and childhood. Prerequisites: Bioch. 35, F.N. 457.

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. The Survey Method in Foods and Nutrition (2) Study of survey technique as a tool in the assay of food adequacy and nutritional status. *Miss Dodds*

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition. *Miss Pike*

FORESTRY

Peter W. Fletcher
Director of the School of Forestry
102 Forestry Building

Degrees Conferred: M.S., M.F.
Graduate Faculty: Professors Bartoo, Chisman, Fletcher, Goddard, Humphrey, McDermott, Norton, and White; Associate Professor Ward; Assistant Professors Gerhold, Murphey, Schemnitz, Sopper, and Tsoumis.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science. The M.F. and M.S. degrees may be granted in the technological programs and the M.S. degree in the scientific programs.

Attention is called to the Ph.D. programs available in such related fields as agricultural economics, agronomy, botany, entomology, genetics, and plant pathology.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in timber management, wildlife habitat management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar program emphasizing biological science, economics, and applied mathematics provides the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engineering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

FORESTRY (FOR)

416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
445. Improvements (3)
450. Advanced Mensuration (3)
466. Forest Resource Management (3)
469. (W.U. 469) Problems in Forestry and Forest Products (1-6 per term)
480. Policy and Administration (3)

504. (W.U. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 78.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Bot. 409 or 516.

510. Forestry Seminar (1 per term) Current problems of forest research presented as weekly seminar reports. May be repeated with additional credit for each term's work.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerqeuisite: Bot. 22.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 78, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 70.

590. The Lumber Industry (3) Relation of the lumber industry to national economy and world trade; lumberman's associations; lumber accounts.

WOOD UTILIZATION (W U)

404. Physical and Mechanical Properties of Wood (3)
405. Adhesives and Glued Wood Products (3)
424. (Bot. 424) Commercial Tropical Woods (3)
435. Seasoning and Preservation (3)

437. Wood Micro-Technique (3)
462. Defects in Wood (3)
469. (For. 469) Problems in Forestry and Forest Products (1-6 per term)
491. Logging and Lumbering (3)
492. Lumber Properties and Usage (3)
495. Lumber Manufacturing Processes and Cost Analysis (3)
497. Small Sawmills (3)

502. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose. Pulping quality, fiber measurements.

504. (For. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

510. Wood Utilization Seminar (1 per term)

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

540. Chemical Utilization of Wood (3) Wood as a chemical raw material; its chemical properties and conversion processes.

FUEL TECHNOLOGY

Howard B. Palmer, *Head of the Department*
316 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Given, Palmer, and Walker; Associate Professors Austin, Essenhigh, and Vastola; Assistant Professor Polansky.

In their programs of courses and research, students may emphasize the chemical, physical, or engineering aspects of solid, liquid, or gaseous fuels. Students are accepted with undergraduate majors in chemistry, chemical engineering, mechanical engineering, physics, or fuel technology.

The department has special facilities for research on high temperature gaseous reactions; reactions of free radicals; combustion of pulverized coal and oil sprays; dust explosions; fuel cells; formation, structure, physical properties, and reactions of carbons and graphites; chemistry of coal macerals; reactions in plasmas; structure and reactions of coals; and special organic reactions of fuel-related materials.

Each student is encouraged to develop a strong minor in the field most closely related to his area of specialization in fuel technology.

FUEL TECHNOLOGY (F T)

400. Fuel Technology Research and Design (1-3)
402. Chemicals from Fuels (2) *Mr. Given*
405. Combustion Calculations (3) *Mr. Austin*
406. Gaseous Combustion (3) *Mr. Palmer*
408. Combustion and Gasification Engineering (4) *Mr. Essenhigh*
409. Cokes, Carbons, and Graphites (2) *Mr. Polansky*

410. Fuel Technology Laboratory (2) *Mr. Polansky and Staff*
414. Fuel Engineering Analysis (2) *Mr. Austin*
415. New Sources of Energy (2) *Mr. Vastola*

503. Coalification and Coal Chemistry (3) Chemical changes during the coalification process; chemical and physical constitution and classification of coals; relations between coal chemistry and constitution. Prerequisite: Chem. 31. *Mr. Given*

506. Kinetics of Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of coals and carbons. Prerequisites: Chem. 451, F.T. 409. *Mr. Walker*

510. Special Topics in Fuel Technology (1-6 per term)

511. Fuel Technology Seminar (1 per term) Selected topics from current fuel technology research examined and discussed.

512. High Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.T. 406. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.T. 406. *Mr. Palmer*

515. Catalysis of Fuel Reactions (2) Principles of chemisorption and catalysis; mechanisms of specific catalytic reactions and practical aspects of catalytic processes in the fuels industries. Prerequisite: Chem. 452. *Mr. Walker*

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in fuel technology studies are listed under Mineral Sciences.*

GENERAL FAMILY STUDIES

Rose M. Cologne
In Charge of Graduate Programs in General Family Studies
19D Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Because this program is planned for teachers in secondary schools or small colleges and others who wish to become proficient in several areas of home economics, the student must have a strong home economics background for admission.

The major for the M.S. or M.Ed. degree consists of a minimum of 6 credits in each of three areas of home economics. Three areas in this field are also the basis for the major at the doctoral level. However, the minimum credit requiremnts in each area are established after consultation with a committee which reviews all previous work. The student chooses a minor field of educational foundations or, if sufficient competence in educational foundations is demonstrated, one of the applied fields, such as home economics education, secondary education, or higher education.

GENERAL FAMILY STUDIES (G F S)

502, 502v. Home Economics and American Society (3) Family life education in relation to a democratic culture; emphasis upon the interrelatedness of socio-economic problems and the American family.

503. Graduate Seminar in Home Economics (1) *Miss G. M. Henderson*

516, 516v. Methods of Research in Home Economics (3) Review of problems and techniques of research in home economics. Required of all graduate students in home economics.

530. Selected Problems in General Home Economics (1-6)

GENETICS

James E. Wright, *Chairman of the Committee on Genetics*
307 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate programs are offered in the fields of theoretical and applied genetics. Courses in genetics and breeding are given by various departments. The basic and theoretical courses are listed under identical numbers in the Departments of Botany and Zoology. Courses dealing with genetic principles as applied to specific organisms are offered in the Departments of Agronomy, Animal Husbandry, Dairy Science, Horticulture, Microbiology, and Poultry Science. The graduate committee for majors shall be appropriately represented by members of theoretical and applied phases who shall have the responsibility and jurisdiction for determining course work and research acceptable in satisfying degree requirements.

For entry as a major in this field no fewer than 15 credits in basic biology and 15 credits in the areas of chemistry, mathematics, and physics are required.

The following courses are available in genetics or breeding, and their descriptions may be found under the offerings of the several departments: Agro. 411, 509, 510, 582; A.H. 501, 505; Bact. 516; Bot. (Zool.) 405, 422, 505, 524, 528, 533; D.Sc. 513; Hort. 444, 503, 520; Pty.Sc. 402, 505.

GEOCHEMISTRY

John C. Griffiths
Head of the Department of Geochemistry and Mineralogy
114 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Bates, Brindley, Greig, Griffiths, Keith, Osborn, Roy, Tuttle, and Vand; Associate Professors Barnes, Burnham, Wright, and Wyllie; Assistant Professor Dachille; Mrs. Roy.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOCHEMISTRY (GCHEM)

456. Introductory Geochemistry (2) *Mr. Keith*
457. Geochemical Prospecting (2) *Mr. Barnes*

501. Research (1-10 per term) Research in geochemistry.

509. Geochemistry Seminar (1 per term)

510. Problems in Geochemistry (1-9) Laboratory and library study of special problems.

512. Crystal Chemistry of Nonmetallic and Defect Solids (2-4) Relation of structure to ionic size, charge, polarizability; influence of p-t environment; chemical-structural defects, diffusion, transitions, and reactions in solids. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Mr. Osborn*

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Weber*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Herzog*

518. Isotope-Ratio Variations in Nature (2) Theoretical basis and observations of isotope fractionation in nature: paleotemperature scale; temperatures of formation of ore deposits and other rocks. *Mr. Weber*

519. Cosmochemistry and Nucleogenesis (2) Distribution and composition of matter; origin of solar system and earth, of constituent nuclides, of life. *Mr. Herzog*

520. P-T-X Phase Relations in Mineral Systems (2) Phase equilibrium in mineral systems with pressure as a variable. Prerequisite: Gchem. 513. *Messrs. Tuttle and Wyllie*

522. Geochemistry of Aqueous Systems (3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, P_{O_2}-pH relations applied to ground water, sea water, hydrothermal fluids. *Mr. Barnes*

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Mineral Sciences.*

GEOGRAPHY

Allan L. Rodgers, *Head of the Department*
202 Mineral Sciences Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Deasy, Griess, Lewis, Miller, and Rodgers; Assistant Professor Simkins.

Students may concentrate on physical geography, human geography, political geography, economic geography, cartography, or some aspect of regional geography.

Because physical geography is a branch of the physical sciences and human, political, and economic geography are branches of the social sciences, a student may enter graduate work under either of two options. Option 1, for the student who wishes to specialize in physical geography, requires the completion of 18 undergraduate credits in geography and 20 credits in mathematics and biological and physical sciences, including at least 6 credits in geology. Option 2, for the student who wishes to specialize in human, political, or economic geography, requires 18 undergraduate credits in geography plus 20 credits in the social sciences, including at least 3 in economics.

GEOGRAPHY (GEOG)

401.	Historical Geography of North America (3)	*Mr. Zelinsky*
402.	Cultural and Anthropo-geography (3)	*Mr. Zelinsky*
405.	Geography of Population (3)	*Mr. Zelinsky*
407.	Geography of Settlement (3)	*Mr. Simkins*
410.	Cartography—Map Design and Construction (3)	*Mr. Deasy*
420.	Urban Geography (3)	*Mr. Rodgers*
427.	Geography of the Soviet Union (3)	*Mr. Rodgers*
430.	Agricultural Geography (3)	*Mr. Whitney*
433.	Regional Climatology (3)	*Mr. Wernstedt*
434.	Regional Physiography (3)	*Mr. Lewis*
442.	Geography of Europe (3)	*Mr. Miller*
443.	Geography of the Orient (3)	*Mr. Whitney*
444.	Geography of Africa (3)	*Mr. Gould*
445.	Geography of Southern Asia (3)	*Mr. Wernstedt*
452.	Interpretation of Aerial Photographs (3)	*Mr. Deasy*
460.	Political Geography (3)	*Mr. Lewis*
480.	Geography of Manufacturing (3)	*Mr. Miller*
490.	Physical Geography for Teachers (3)	*Mr. Lewis*

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The literature of some phase of physical geography with emphasis on procedures for organizing material for classroom reports and discussions.

505. Economic Geography Seminar (3-12) The literature of some phase of economic geography with emphasis on procedures for organizing material for classroom reports and discussions.

506. Cultural and Political Geography Seminar (3-12) The literature of some phase of cultural and political geography with emphasis on procedures for organizing material for classroom reports and discussions.

507. Development of Geographic Thought (1-6) Critical analysis of the growth of geographic thought from antiquity to the present; emphasis on structure of modern geography.

510. Physical Geography Research (3-10) Original study in physical geography: a field problem or detailed library investigation with analysis and presentation of data.

511. Economic Geography Research (3-10) Original study in economic geography: a field problem or detailed library investigation with analysis and presentation of data.

512. Cultural and Political Geography Research (3-10) Original study in cultural and political geography: a field problem or detailed library investigation with analysis and presentation of data.

GEOLOGY

Lauren A. Wright
Head of the Department of Geology and Geophysics
110 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Jahns, Krynine, Ridge, Spackman, Swartz, and Wright; Associate Professors Lattman, Schmalz, Scholten, and Williams; Assistant Professors Dutcher and Parizek.

Students may specialize in stratigraphy, paleontology, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, marine geology and chemical oceanography, coal geology, and geology of metallic and nonmetallic deposits.

Prerequisites for admission include 25 credits in an approved combination of chemistry, physics, mathematics, and biological sciences, and at least 18 credits in geology and mineralogy.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOLOGY (GEOL)

400.	Geology for Teachers (3)	
410.	Structural Geology (3)	
420.	Paleobotany (3)	*Mr. Spackman*
421.	Introduction to Coal Petrology (3)	*Mr. Williams*
422.	Introductory Palynology (3)	*Mr. Spackman*
430.	Paleontology (3)	*Mr. Swartz*
440.	Marine Geology (3)	*Mr. Schmalz*
451.	Economic Geology (3)	*Mr. Ridge*
452.	Introduction to Hydrogeology (3)	*Mr. Parizek*
461.	Geology of the United States (3)	
462.	Principles of Geomorphology (3-6)	*Mr. Lattman*
470.	Introduction to Field Geology (3)	*Mr. Jahns*
472.	Field Geology (5)	*Mr. Scholten*
481.	Geology of Oil and Gas (3)	*Mr. Scholten*
490.	Paleozoic Stratigraphy (3)	*Mr. Swartz*
491.	Stratigraphy Field Trips (1)	*Mr. Swartz*
492.	Pennsylvanian Stratigraphy (3)	*Mr. Williams*

*500. Geology Seminar (1-9) Presentation, at weekly departmental meetings, of topics selected from geological literature.

†501. Stratigraphy (3-12) Principles of stratigraphic classification, lithofacies and biofacies, faunal zonation, correlation, sedimentation, and paleogeography, illus-

*Credits to be arranged, 1 to 6 per term.
†Credits to be arranged, 3 to 6 per term.

trated by stratigraphy of classical geologic regions: (a) Pre-Cambrian; (b) Paleozoic; (c) Mesozoic; (d) Cenozoic. Prerequisite: Geol. 430. *Mr. Swartz*

†503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Swartz*

504. History and Foundations of Geology (2-3) Development through the ages of scientific thought in the earth sciences. *Mr. Krynine*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology. *Mr. Lattman*

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

515. Ore Microscopy (2-3) Theory and use of the ore microscope in identifying ore minerals in polished section, establishing paragenetic sequences, determining manner of deposition.

‡517. Sediments of the World (1-9) Microscopic and field studies of representative American and foreign rock suites; correlation with paleogeographic, geotectonic, economic data. Prerequisites: Min. 512, 514. *Mr. Krynine*

520. Seminar in Paleobotany (2-6) Current and classic literature concerning evolution, paleoecology, and geologic history of vascular plants. *Mr. Spackman*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Spackman*

526. Problems in Palynology (3-9) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.

530. Geological Problems (3-6) Study, from the literature, of a selected geological problem. Prerequisite: 10 credits in geology and mineralogy.

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, land forms, effects in periglacial regions. *Mr. Lattman*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462. *Mr. Lattman*

551. Geotectonics (3-6) Tectonic principles and elements: nature and development of geosynclines, island arcs, mountain structures, stable masses, cratons, mobile belts. *Mr. Scholten*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and microscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks.

†Credits to be arranged, 3 to 6 per term.
‡Credits to be arranged, 1-3 per term.

571. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

590. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces. Required each spring of all graduate students in geology.

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Mineral Sciences.*

GEOPHYSICS

Lauren A. Wright
Head of the Department of Geology and Geophysics
110 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bell and Howell; Associate Professor Herzog; Assistant Professors Crowe and Lavin.

Students may specialize in geophysical prospecting, seismology, gravity, well logging, tectonics, physical properties of rocks, radioactive age determinations, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, geology, and mineralogy; and at least 12 credits of intermediate-level work in any one or a combination of these subjects.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOPHYSICS (GPHYS)

406. Physics of the Earth (3) *Mr. Howell*
407. Well Logging (3) *Mr. Crowe*
408. Geophysical Surveying (3) *Mr. Crowe*
416. Electrical Surveying (2) *Mr. Crowe*
417. Seismic Surveying (3) *Mr. Howell*
418. Potential Theory Applied to Earth Problems (3) *Mr. Crowe*
426. Geophysics Field Work (1-4) *Messrs. Crowe and Lavin*

500. Geophysical Seminar (1 per term) Discussion of geophysical reports and papers; scientific outlook.

501. Research (1-10 per term) Research in geophysics.

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders. *Mr. Howell*

503. Special Studies in Geophysics (1-9) Special studies of the theories of geophysical methods.

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting. *Mr. Howell*

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth. *Mr. Howell*

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration. *Messrs. Herzog and Wright*

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineral Sciences.*

GERMAN

Philip A. Shelley, *Head of the Department*
229 Sparks Building

Degrees Conferred: Ph.D., M.A., M.Ed.
Graduate Faculty: Professors Buffington, de Levie, and Shelley; Associate Professors Beare, Lüders, and Striedieck.

There is opportunity for major emphasis upon either literature or philology. Minimum qualifications for admission include 18 undergraduate credits in German; provision is made, however, for admission with limited deficiencies.
A thesis is required of all M.A. candidates in this major.

GERMAN (GER)

401. Advanced Stylistics (3)
430. History of the German Language (3) *Mr. Buffington*
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9) *Mr. Shelley*
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3) *Messrs. Buffington and de Levie*
469. Goethe's Life and Works (3) *Messrs. Buffington and de Levie*
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3) *Miss Lüders*

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees. *Messrs. Striedieck and de Levie*

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields. *Messrs. Striedieck and de Levie*

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language. *Messrs. Shelley and Beare*

*No graduate credit is given for this course.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.
Messrs. Buffington and Ebbinghaus

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.
Messrs. Buffington and Ebbinghaus

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D. *Mr. Ebbinghaus*

523. Gothic (3) Introduction to historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English. *Mr. Ebbinghaus*

524. Old Saxon (3) Introduction to Old Saxon grammar; readings in Old Saxon texts, both prose and poetry. Suitable for advanced students in English.
Mr. Ebbinghaus

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English. *Mr. Ebbinghaus*

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)
Mr. Beare

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6) *Messrs. Buffington and de Levie*

561. Seminar in Post-Idealistic Literature (3-6) *Miss Lüders*

571. Seminar in Modern German Literature (3-6) *Miss Lüders*

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

HIGHER EDUCATION

Hugh S. Brown, *in Charge of Graduate Programs in Higher Education*
166 Chambers Building

Degree Conferred: D.Ed.
Graduate Faculty: Professors Brown, Patrick, and Wellington.

Graduate students with any undergraduate major may enter the program without other prerequisites. The following courses in higher education are listed under the offerings of the Department of Educational Services: Ed.Ser. 545 to 552 inclusive and 555 (see page 95). To complete a program to meet the student's needs, additional courses will be selected from other departments of the University.

Candidates for advanced degrees in other fields may elect higher education as a minor, subject to the restrictions concerning minors.

HISTORY

Robert K. Murray, *Head of the Department*
116 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Brown, Dahmus, DeNovo, Forster, Gray, Klein, Murray, Pundt, and Rayback; Associate Professors Green, Hassler, Hoogenboom, McNall, and Thaden; Assistant Professor Pixton.

Graduate work is offered in the following fields of history: ancient, medieval, early modern European, modern European, colonial American, 19th century American, modern American, British, Russian, Latin American, Far Eastern, Middle Eastern, political (European or American), diplomatic (European or American), economic (European or American), social and cultural (European or American).

The candidate for the doctor's degree must pass examinations in four of the above fields, one of which is his dissertation field. He must also pass an examination either in a fifth field of history and a single cognate field, or in a study area made up of a number of academic disciplines related to his dissertation field. The candidate for the master's degree selects one broad field (such as modern European or American) for examination and thesis purposes. About half his course credits are selected outside the examination field. He also must take work in a cognate field. A thesis is required of all M.A. candidates in this major.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present.

HISTORY (HIST)

401.	Ancient Civilization (3)	
403.	The Middle Ages from Constantine to the Crusades (3)	*Mr. Dahmus*
404.	The Middle Ages from the Crusades to the Renaissance (3)	*Mr. Dahmus*
408.	Intellectual History of the Middle Ages (3)	*Mr. Dahmus*
410.	Renaissance and Reformation (3)	*Mr. Green*
413.	The Age of Absolutism (3)	*Mr. Green*
417.	Nineteenth Century Europe (3)	*Messrs. Forster and Krantz*
419.	Recent European History (3)	*Mr. Forster*
422.	History of the American Frontier (3)	*Mr. McNall*
425.	History of American Political Parties (3)	*Mr. Hoogenboom*
427.	The Diplomatic History of the United States (3)	*Mr. DeNovo*
428.	American Military History (3)	*Mr. Hassler*
431.	Colonial and Revolutionary America (3)	*Mr. Frantz*
432.	The Formative Period of American History (3)	*Mr. Brown*
433.	The Middle Period of American History (3)	*Mr. Klein*
434.	The United States in Civil War and Reconstruction (3)	*Mr. Hassler*
435.	The Emergence of Modern America (3)	*Messrs. Murray and Hoogenboom*
436.	Recent American History (3)	*Mr. Murray*
440.	History of England, 1485-1760 (3)	*Mr. Linker*
441.	English History Since 1760 (3)	*Mr. Linker*
442.	History of Russia to 1861 (3)	*Mr. Thaden*
443.	History of Modern Russia (3)	*Mr. Thaden*
444.	Eastern Europe in Modern Times (3)	*Mr. Thaden*
447.	Social and Economic History of Europe Since 1750 (3)	*Mr. Pundt*
448.	Intellectual and Cultural History of Modern Europe (3)	*Mr. Krantz*

452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
454. Economic Development of the United States (3) *Mr. McNall*
456. History of American Labor (3) *Mr. Rayback*
460. Latin America and the United States (3) *Mr. Gray*
461. Social and Cultural History of Latin America (3) *Mr. Gray*
471. History of Modern China (3) *Mr. Johnson*
481. The Middle East in Modern Times (3) *Mr. Krantz*

501. Historical Method (3) *Mr. Klein*
502. Historiography (3) *Mr. Pundt*
504. Medieval Civilization (3-9) *Mr. Dahmus*
505. The Age of the Reformation (3-6) *Mr. Green*
508. Studies in European History, 1600-1789 (3-6) *Mr. Pundt*
509. Europe Since 1789 (3-6) *Mr. Forster*
512. Studies in Pennsylvania History (3-6) *Mr. Klein*
520. Colonial and Revolutionary America (3-6)
533. The United States, 1783-1860 (3-6) *Mr. Klein*
534. The United States, 1860-1900 (3-6) *Messrs. Brown and Hassler*
536. The United States in the 20th Century (3-6) *Messrs. Murray and Hoogenboom*
538. Diplomatic History of the United States (3) *Mr. DeNovo*
539. Economic History of the United States (3) *Mr. McNall*
540. Studies in British History (3-6) *Mr. Linker*
545. Studies in Russian and Slavic History (3-6) *Mr. Thaden*
550. Problems in History (3-6)
562. Seminar in Latin-American History (3-6) *Mr. Gray*
563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Gray*
599. Readings in History (3)

HOME ART

Ruth H. Smith, *Acting Chairman of the Division*
258 Home Economics South

A candidate for an advanced degree may choose a minor in home art upon approval by his major department. However, no advanced degree is offered in this field.

FAMILY HOUSING AND HOME ART (FH HAR)

401. Home Furnishings for the Family (3)

*433. Advanced Home Crafts (2-12)
440. Advanced Home Furnishing Problems (3)
441. Special Problems in Home Furnishings (3)
470. Housing Problems and Policies (3)

515. Backgrounds of the Home Arts (3) Evaluation of useful objects in respect to their form, function, and time; selections for exhibition. Prerequisites: F.H.H.Ar. 216 or Art 15 or A.Ed. 106, and A.A.H. 1 or F.H.H.Ar. 240.

530. Problems in Family Housing and Home Art (1-6) Individual investigation, analysis, and presentation.

541. Art in the Environment (3) Approach based upon human needs with consideration of materials in the light of their use in home living. Prerequisite: Art 14 or A.Ed. 105 or F.H.H.Ar. 440.

HOME ECONOMICS EDUCATION

Marjorie East, *Head of the Department*
116B Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors East and Hatcher; Associate Professor Ray.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

For admission the student must present approximately 50 credits of undergraduate work from the following areas: home economics education, education and/or psychology, aspects of home economics; the physical and biological sciences; and the social sciences.

HOME ECONOMICS EDUCATION (HE ED)

406, 406v. Teaching Aids in Family Life Education (1-4)
427, 427v. Family Life Education (3)
443, 443v. Adult Homemaking Education (3)
463, 463v. Senior Seminar (2)
†466, 466v. Student Teaching (9)
477, 477v. Curriculum Development for Home Economics in Secondary Schools (3)
478, 478v. Appraising Student Progress in Education for Family Living (3)
479, 479v. Readings in Home Economics Education (1-4)
480, 480v. Problems in Teaching Home Economics (3-6)

502, 502v. Home Economics Instruction at the College Level (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers. *Mrs. East*

503, 503v. Home Economics Teacher Education (3) Organization of college

*Not more than 2 credits in each field.
†A grade point average of 2.2 in all previous work is prerequisite to each course in student teaching.

programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics. *Miss Hatcher*

504, 504v. Educational Issues and Home Economics (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience. *Mrs. East*

510, 510v. Educational Leadership in Home Economics (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education curriculum and two years' teaching experience in home economics. *Mrs. East*

518, 518v. Evaluation in Family Life Education (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision. *Miss Hatcher*

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in education for family living. Conferences and guidance relative to individual research problems.

526, 526v. The Community Program in Family Life Education (2-3) Ways of discovering community needs and resources; methods of developing the community program in family living; leadership education for the lay member of the community.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE

Darrell E. Walker, *Head of the Department*
101 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Fleming, Hitz, Larson, Mastalerz, Meahl, Odland, and Walker; Associate Professors Bergman, McArdle, Ritter, Smith, and Tukey; Assistant Professors Creech and Pfahl.

Students may specialize in propagation, production, processing, breeding, nutrition, and other physiological studies of horticultural crop species.

Prerequisites for admission vary according to area of specialization; but basic courses in chemistry, mathematics, and the biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

HORTICULTURE (HORT)

412. Storage of Horticultural Crops (3) *Mr. Ritter*
424. Advanced Olericulture (3-6) *Mr. Odland*
425. Advanced Fruit and Vegetable Processing I (3) *Mr. McArdle*
426. Advanced Fruit and Vegetable Processing II (3) *Mr. McArdle*

427. Advanced Floriculture (3) *Mr. White*
428. Advanced Floriculture (3) *Mr. Mastalerz*
444. Advanced Plant Breeding (3-6) *Mr. Craig*
447. Problems in Horticulture (1-9)
450. Fruit Science (3) *Mr. Ritter*
453. Nursery Principles and Practice (3) *Mr. Brewer*
456. Problems in Nursery Practice (3) *Mr. Brewer*

500. Ecology of Fruit Plants (3) Factors limiting the distribution and intensity of culture of fruit species and varieties and effect of environmental factors on cultural practices. Spring term, even years. *Mr. Tukey*

501. Experimental Problems in Pomology (2-12) Investigation of problems involving review of literature, field and laboratory research. *Mr. Hitz*

503. Experimental Plant Breeding (2-12) Problems based mainly on research work of the department, with review of experimental methods and literature. Prerequisite: Hort. 444. *Mr. Walker*

504. Experimental Problems in Olericulture (2-9) Investigation of problems involving review of literature, field and laboratory research. Prerequisite: Hort. 424. *Mr. Odland*

505. Problems in Vegetable Production (2-6) Methods used in the more valuable contributions to vegetable production. Prerequisite: Hort. 424. *Mr. Odland*

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. Winter term, odd years. *Mr. Ritter*

513. Experimental Problems in Ornamental Horticulture (2-12) Review of research in ornamental horticulture, with original investigations. *Mr. Meahl*

514. Propagation of Ornamental and Fruit Plants (3) Factors affecting the asexual and sexual propagation of fruit and ornamental plants. *Mr. Meahl*

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

519. Seminar on the Genetics of Horticultural Crops (1 per term) Review of current research publications on the genetics of horticultural crops. Each student presents one or more reviews of literature on assigned topics.

520. Seminar on the Breeding of Horticultural Crops (1 per term) Each student presents one or more reviews of literature on assigned topics.

523. Propagation and Improvement of Vegetable and Flower Crops (3) Methods and special techniques in breeding of flowers and vegetables; maintenance of seed stocks and seed production. Prerequisite: Hort. 444. Fall term, even years. *Mr. Odland*

524. Experimental Procedures in Horticultural Research (3)

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years. *Mr. Tukey*

526. Experimental Problems in Floriculture (2-12) Greenhouse research and review of literature. Prerequisite or concurrent: Hort. 427, 428. *Mr. Mastalerz*

527. Experimental Problems in Nutrition of Horticultural Crops (2-12) Review of current research; problems for independent investigation. *Mr. Smith*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

INDUSTRIAL ARTS EDUCATION

Herbert A. Smith, *Head of the Department of Secondary Education*
168 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors McGarey and Smith; Associate Professor Pendered.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved curriculum in industrial arts is required for admission.

INDUSTRIAL ARTS (I ART)

400. Shop Management and Layout (3)
407. Curriculum Materials and Methods in Industrial Arts (4)
470. Problems in Senior High School Industrial Arts (3)

574. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. Problems in Industrial Arts Education (2-3) Subject matter, projects, methods of manual and informational teaching, aids and devices, selection of text and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. Testing in Industrial Arts (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and grading; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. Seminar in Industrial Arts (2-9) Directed intensive study, investigation, or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING

BENJAMIN W. NIEBEL, *Head of the Department*
203 Engineering C

Degrees Conferred: M.S., M.Eng.
Graduate Faculty: Professors Niebel and Thuering; Assistant Professors Draper and Raphael.

Graduate study and research are conducted in operations research, linear programming, queuing theory, process design, systems engineering, and experimental design. Opportunities also exist for advanced study in automation, production engineering, product design for production, work measurement, costs and budgets, tool design, methods analysis, personnel management, and management controls.

For admission a student must have graduated from an accredited school with a major in industrial engineering. Graduates of other accredited engineering curriculums may be admitted after completing 27 credits in industrial engineering.

INDUSTRIAL ENGINEERING (I E)

400. ENGINEERING FOR PRODUCTION (3) *Mr. Niebel*
402. ENGINEERING ECONOMY (3) *Messrs. Moss, Raphael, and Guild*
404. MANAGEMENT SCIENCE (3) *Messrs. Caldwell and Raphael*
406. FACTORY PLANNING (2) *Messrs. Thuering, Draper, and Raphael*
422a,b,c,d,e,f. INDUSTRIAL ENGINEERING PROBLEMS (2-12) *Messrs. Niebel, Thuering, Moss, Guild, and Addison*
423. QUALITY CONTROL (2) *Messrs. Thuering and Moss*
424. JOB EVALUATION (3)
425. METHODS OF INDUSTRIAL OPERATIONS RESEARCH (3) *Mr. Guild*
426. INDUSTRIAL AUTOMATION (3) *Mr. Bowman*
427. ADVANCED METAL CASTING (3) *Mr. Draper*
428. FOUNDRY ENGINEERING (3) *Mr. Draper*
430. INDUSTRIAL LEADERSHIP (3) *Mr. Caldwell*
432. INDUSTRIAL ENGINEERING LECTURES (1-3)

501. MANUFACTURING METHODS (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture. *Messrs. Niebel, Draper, and Ham*

502. MANAGEMENT METHODS (3-6) Scientific management, including management controls and mathematical programming; research on special problems. *Messrs. Thuering and Raphael*

503. PERSONNEL RELATIONS (2-8) Research on special topics. *Messrs. Williamson and Addison*

505. GRAPHICAL COMPUTATION (2-6) Construction of natural and logarithmic scales, applications of various coordinate papers and construction of nomographic or alignment charts; determination of empirical formulae from engineering data. *Mr. Thuering*

506. TIME AND MOTION STUDY (3-9) Methods of research in motion and time study; critical analysis of current literature. *Mr. Niebel*

507. BUDGETARY CONTROL AND STANDARD COSTS (3-6) Divisional budgets as control media; establishing standard cost data, standard cost accounting procedures, and use of cost variances in controlling manufacturing operations. Prerequisite: I.E. 335.

513. Data Processing and Programming (3) Theory and techniques in systems analyses applied to the programming of procedures and operations. *Mr. Raphael*

JOURNALISM

Robert M. Pockrass, *in Charge of Graduate Programs in Journalism*
211 Carnegie Building

Degree Conferred: M.A.
Graduate Faculty: Professors Brown, Goodwin, and Marbut; Associate Professors Froke, Harrison, and Pockrass; Assistant Professor Norris.

The program is designed to give students a critical insight into the theory and practice of communication and the mass communications industries, as well as an introduction to research on communications problems. Fulfilling the requirements for this degree should qualify students to advance in positions of responsibility and leadership in the professions of journalism, advertising, broadcasting, and public relations; in communications research; or in education.

The program is designed for students who have a groundwork of technical and professional education or experience in journalism and communications. Such students are admitted under Plan A. Students lacking a knowledge of the fundamentals of journalism and communications may enroll under Plan B and be required to take up to 18 credits in basic courses needed to make up this deficiency.

A thesis is required of all M.A. candidates in this major.

JOURNALISM (JOURN)

401. Critics and Ethics of the Mass Media (2) *Mr. Harrison*
405. Comparative Foreign Journalism (2) *Mr. Marbut*
406. Evaluation and Uses of Mass Communications Research (3)
421. Editorial Interpretation (3)
422. Cultural Aspects of the Mass Media (3) *Mr. Pockrass*
424. Public Affairs Reporting (4) *Mr. Dulaney*
430. Journalism in the Schools (3-6) *Mr. Vairo*
441. Advanced Advertising Copywriting (3)
443. Advertising Campaigns (3)
444. Advertising in Contemporary Society (3) *Mr. Norris*
466. Public Relations Problems (3)
468. Law of Mass Communications (3) *Mr. Smith*
480. Media Management (3)
485. Comparative Theories of Press Systems (3) *Mr. Norris*
492. (Brcst. 492) Public Affairs Broadcasting (3) *Mr. Froke*
499. Independent Study in Mass Communications (2-6) *Mr. Goodwin*

504. Seminar in the History of Mass Communication (3) *Mr. Marbut*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes. *Mr. Marbut*

506. Seminar in Communications Research (3-6) Methodology of research in media, content, audiences; experimental, case, and field studies; data processing and analysis; report writing; individual projects. *Mr. Pockrass*

508. The Literature of Journalism (3) *Mr. Brown*

513. Current Problems in News Reporting and Editing (3) Securing, writing, display, and treatment of the news; newsroom policies and ethics. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427, Psy. 429, or Soc. 431. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Goodwin*

540. Seminar in Advertising Problems (3) *Mr. Norris*

MATHEMATICS

James B. Bartoo, *Head of the Department*
230 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors R. Ayoub, Bartoo, Benton, Curry, A. Frink, O. Frink, E. Johnson, Kanwal, Krall, Mitchell, Mrowka, Ribeiro, Schoenfeld, and Sheffer; Associate Professors Anderson, C. Ayoub, Harkness, Hunter, D. G. Johnson, Kist, Mack, McCammon, Pervin, and Pour-El; Assistant Professors Barnes, Howard, Rabenstein, Rung, and Stevens.

Graduate courses in all the principal branches of mathematics are offered each year. The department is prepared to direct research in a variety of fields, including function theory, abstract algebra, topology, number theory, statistics, numerical analysis, and all aspects of mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

To be admitted to the M.A. or Ph.D. program without undergraduate deficiency, an applicant should have completed at least three courses in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) and 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree.

For the M.A. degree the department permits the substitution, in place of the thesis, of a term paper and a written examination based on the content of Math. 420-421, 480-481, 473, 501, and 508. The term paper may be one of the following types: (a) a small piece of mathematical research, (b) an expository paper on some area of mathematics, or (c) an expository paper on a narrower area which is to exhibit a sound knowledge of the literature and the use of library sources, and which is to be completed in a 10-week period.

The written examination mentioned above is also required of graduate students who have not taken their master's degree at this University. It, together with one language examination in French, German, or Russian, must be passed by all M.A. and Ph.D. candidates before they have scheduled more than 48 graduate credits. Failure to fulfill these requirements will result in the dismissal of the student.

All first-year students who are candidates for the M.A. or Ph.D. degrees are required to enroll in a special seminar course.

To be admitted to the M.Ed. program without undergraduate deficiency in mathematics, an applicant should have at least 24 credits in mathematics including at least 6 at the intermediate level beyond calculus.

Special courses have been instituted for the training of teachers. Among these are Math. 403, 407, 412, 413, 414, 415, and 416. These are acceptable for the satisfaction of credit requirements only for the M.Ed. and D.Ed. degrees.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. Fourier Series and Boundary Value Problems (3)
407. Foundations of Algebra and Geometry (3)
409-410. Probability and Statistics (3 each)
411. Finite Differences (3)
413-414. Mathematics of Science for Teachers (3 each)
415. Survey of Modern Mathematics for Teachers (3)
416. Mathematical Logic for Teachers (3)
417. Vector and Tensor Analysis (3)
419. Analytical Mechanics (3)
420-421. Introduction to Analysis (3 each)
428. (Phil. 428) Logical Theory (3)
431. Differential Equations (3)
441. Matrix Algebra (3)
451-452. Introduction to Applied Mathematics (3-6 each)
453. Mathematics for Digital Computers (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elements of Set Theory and Topology (3)
480-481. Introduction to Modern Algebra (3 each)
491. Topics in Applied Mathematics (3-9)
498. Mathematics Seminar (1-6)

500. Analytical Mechanics (3) An exposition of rigid dynamics, the potential function, and Lagrange's equations. Prerequisite: Math. 419 or Phys. 461.

501-502. Theory of Functions of a Real Variable (3 each) Theory of real functions, sets, measure, derivatives, and integrals. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisites: Math. 44, 421.

508-509. Theory of Functions of a Complex Variable (3 each) Development of the complex number system; theory of analytic functions. Prerequisite: Math. 421.

510. Theory of Groups (3) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisites: Math. 480 441; or Math. 481.

513-514. Advanced Analytic Geometry (3 each) Introduction of homogeneous coordinates and their use in the study of projective properties. Prerequisite: Math. 43.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

516-517. Advanced Probability Theory (3 each) Probability spaces, distribution functions, characteristic functions, convergence theorems, independence, central limit problems, dependence, stochastic processes. Prerequisite: Math. 501.

520-521. Projective Geometry (3 each) General study of the subject from the postulational standpoint. Prerequisite: Math. 43. Alternate years or as required.

522-523. Metric Differential Geometry (3 each) The usual classical treatment of the subject. Prerequisite: Math. 43.

530-531. Topology (3 each) Topological spaces, combinatorial topology, applications to algebra and analysis.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. (Phil.) 428.

534. Theory of Algebraic Numbers (3) Introduction to the number theory of quadratic fields, with study of the theory of ideals in quadratic and higher fields, with application. Prerequisites: Math. 404, 480.

535. Modern Algebra (3) First graduate course in abstract algebra including the basic theory of semigroups, rings, fields, operator groups, and factorization. Prerequisites: Math. 480, 441; or Math. 481.

537. Theory of Fields (3) Selected topics from field theory including extensions and structure of fields; Galois theory; algebraically closed, ordered, and algebraic number fields. Prerequisite: Math. 535.

538. Theory of Rings (3) Selected topics from commutative and noncommutative ring theory including ideals, the Jacobson structure theory, and special classes of rings. Prerequisite: Math. 535.

539. Lattice Theory (3) Selected topics from lattice theory including complete, modular, complemented, and distributive lattices and applications. Prerequisite: Math. 535.

542-543. Theory of Statistics (3 each) Univariate and multivariate distributions, sampling distributions, theory of estimation, statistical hypotheses. Prerequisites: Math. 409, 421.

550-551. (Phil. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Math. (Phil.) 428.

552-553. Numerical Analysis (3 each) Topics from: interpolation and integration with remainder terms; approximation theory; asymptotic expansion; solutions of algebraic, differential, integral equations. Prerequisites: Math. 421, 453.

554. (Phil. 554) Metamathematics (3) Prooftheoretic and modeltheoretic study of systems: Gödel's theorem, relative and absolute consistency proofs, decidability, properties of relational structures, mathematical applications. Prerequisite: Math. (Phil.) 428.

555. Selected Topics in Mathematics for Chemists (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions.

556. (Phil. 556) Recursion Theory (3) Recursive functions; recursive and recursively enumerable sets; equivalent formulations of computability; Church's thesis; related topics from current literature. Prerequisite: Math. (Phil.) 428.

560-561. Theory of Differential Equations (3 each) Prerequisites: Math. 44, 421.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 501.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. Special Topics in Probability and Statistics (3-12)

578. Special Topics in Topology (3-12)

MECHANICAL ENGINEERING

Richard G. Cunningham, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus)
Graduate Faculty: Professors Ambrosius, Calvert, Cunningham, DiIlio, Meyer, Olson, and Shearer; Associate Professors Brickman, DeCarolis, Jenks, Lester, Lestz, and Schmidt.

Graduate programs in mechanical engineering emphasize thermal engineering or design engineering. Courses and facilities permit studies in thermodynamics, fluid mechanics, heat transfer, advanced design engineering, combustion processes, machine dynamics, gas turbines, lubrication, automatic control systems, and power generation and utilization.

To be admitted, a student should be a graduate of an accredited curriculum in mechanical engineering. Graduates of other accredited engineering or physical science curriculums may be admitted, but will be required to make up undergraduate deficiencies without graduate credit.

MECHANICAL ENGINEERING (M E)

401. Mechanical Engineering (3-12)
402. Air Conditioning (3)
403. Rocket Propulsion (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration (3)
412. Heat Transfer (3)

413. Internal Combustion Engines (3)
417. Theory of Engineering Instruments (3)
418. Principles of Turbomachinery (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Machine Design Analysis (3)
453. Bearing Design and Lubrication (3)
455. Automatic Control Systems (3)
457. Advanced Mechanisms (3)

502. Advanced Gas Turbines (3-6) Analytical study of gas turbine compressors and turbines; combustion; complex cycles; recent developments. Prerequisite: M.E. 409.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. Selected Topics in Mechanical Engineering (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Advanced Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions. Prerequisites: M.E. 412, Math. 451.

513. Advanced Heat Transfer—Convection and Radiation (3) Convection heat transfer in laminar and turbulent flow; two-phase heat transfer, transportation, film and ablation cooling, and radiation heat transfer. Prerequisite: M.E. 412.

518. Turbomachinery (3) Similarity considerations and basic equations of turbomachinery; limiting flow conditions; theory and design of vane systems; special topics.

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; two-dimensional supersonic flow; oblique shock waves.

520. Nonsteady Flow of Compressible Fluids (2-4) Method of characteristics; general flow problems; boundaries and discontinuities; interaction of discontinuities; wave diagram techniques and applications.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) The hydrodynamic theory of lubrication and methods of applying it to bearing design, together with a survey of methods of testing lubricants.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

557. Mechanism Synthesis (3) Design and analysis of mechanisms for specific motion and energy requirements; intermittent mechanisms. Prerequisite: M.E. 457.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY

Robert W. Lindsay, *Head of the Department*
5 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Lindsay, Muan, and Read; Associate Professor Bitler; Assistant Professors Hoke and Ryba.

There is opportunity for a student to specialize, both in research and in course work, in chemical metallurgy, physical metallurgy, or mechanical metallurgy. Minor work in any of these specializations is available for students majoring in another field.

The requirements for admission are a satisfactory bachelor's degree in metallurgy, metallurgical engineering, chemistry, chemical engineering, physics, mechanical engineering, or engineering mechanics; or a satisfactory bachelor's degree in another field, provided it has included the equivalents of mathematics through ordinary differential equations; 8 credits in physics; 12 in chemistry; 10 in other scientific, engineering, or mineral science fields; and 10 in metallurgy. Students who lack some of these requirements may be admitted but are required to take the prerequisite courses without being able to apply them toward an advanced degree.

METALLURGY (METAL)

405. Ferrous Metallography (3)
406. Nonferrous Metallography (3)
407. Metallurgical Engineering I (3)
408. Metallurgical Engineering II (3)
409. Metallurgical Investigations I (2)
410. Metallurgical Investigations II (2)
412. Solid State Metallurgy (3)

501. Metallurgical Problems (1-6 per term) Independent study of special problems in metallurgy. *Mr. Bitler*

502. Seminar in Metallurgy (1-6) Conferences, reading, reports, and special lectures.

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution, atom movements. Prerequisites: Chem. 452, Metal. 303, 412. *Mr. Ryba*

513. Advanced Chemical Metallurgy (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 302, 304.

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. Prerequisites: Metal. 511, 513. *Mr. Read*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 513. *Mr. Hoke*

518. Constitution of Metallurgical Systems (3) Application of thermodynamic principles to study of heterogeneous equilibrium in alloy, slag, and slag-metal systems. Prerequisites: Metal. 511, 513.

519. Advanced Ferrous Metallurgy (3) Physicochemical principles applied to reactions in iron- and steelmaking systems, including gas, metal, slag, and refractory phases. Prerequisite: Chem. 452 or Metal. 513. *Mr. Muan*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513. *Mr. Lindsay*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 511, 513. *Mr. Ryba*

524. Advanced Metal Working (3) Elements of mathematical theory of plasticity; metal working processes; measurement of deformations in metal working; theory of metal working. Prerequisite: Metal. 516. *Mr. Hoke*

525. Metal Finishing (3) Metallic coatings and their metallurgical properties; theories and problems of application, utilization, and evaluation. Prerequisite: Metal. 515. *Mr. Read*

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Mineral Sciences.*

METEOROLOGY

Charles L. Hosler, Jr., *Head of the Department*
322 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Blackadar, Hosler, Neuberger, and Panofsky; Associate Professors Danielsen and Stephens; Assistant Professor Duquet.

Candidates in meteorology may specialize in aerosol and cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, atmospheric optics and electricity, macro- and microclimatology, agricultural meteorology, synoptic meteorology, or meteorological instrumentation.

Requirements for admission include mathematics through differential equations and one year of college physics. Students with a strong background in mathematics, physics, or engineering may be admitted with deficiencies but must make up such deficiencies before they are admitted to candidacy for a degree.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
411. Introduction to Synoptic Meteorology (3)
418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)

433. Advanced Synoptic Analytical Techniques (3)
443. Physical Meteorolgy (3)
445. Hydrometeorology (3)
450. Applications of Statistics to Meteorology (3)
451. Thermodynamics of the Atmosphere (3)
452. Hydrodynamics of the Atmosphere (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
492. Meteorological Seminar (1-2)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Mineral Sciences.*

MICROBIOLOGY

Robert W. Stone, *Head of the Department*
204 Patterson Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Cone, Dunne, Ludwig, Reid, Stone, and Zimmerman; Associate Professors Casida, Gentry, Heist, and Lindstrom.

Specialized areas of study include bacterial physiology, soil microbiology, food and industrial microbiology, immunology, and virology. There is opportunity for research in animal disease in cooperation with the Department of Veterinary Science.

Prerequisites for admission are 20 credits in chemistry including quantitative analysis and organic chemistry, and 12 in biological science with a minimum of 8 in microbiology.

BACTERIOLOGY (BACT)

401. General Microbiology (4)
407. Bacteriology Problems (2-9)
410. Immunology and Serology (4)
411. Bacteriological Survey (1)
412. Advanced Bacteriology (4)
413. Soil Microbiology (4)
414. Food Microbiology (4)
416. Industrial Microbiology (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Physiology of Bacteria (2-4) Composition, nutrition, and growth of microorganisms; influence of physical and chemical environment on metabolism.

509. Fermentation (2) Chemical activities of microorganisms; mechanisms of fermentative and oxidative metabolism.

510. Laboratory in Fermentation (2) Laboratory procedures and problems in fermentation to accompany Bact. 509.

512. Bacteriological Techniques (1-6) Practice in special laboratory techniques including manometry, tissue culture, and serology.

515. (V.Sc. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Bact. 410.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in bacteriology and genetics.

MINERAL ECONOMICS

John D. Ridge, *Head of the Department*
207 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Ridge and Schanz; Associate Professor McDivitt.

A student may specialize in the economics of exploration for, and the extraction, beneficiation, and utilization of, the ferrous and nonferrous metals, the nonmetallics, the fuels, and ground water. Work is also offered in property evaluation, analysis of mineral data, and the influence of technological advances on mineral economics.

The requirements for admission are 24 credits in chemistry, physics, and mathematics; 12 in geology, mineralogy, and/or the biological sciences; 9 in mineral economics, economics, commerce, and/or geography; and 6 in mining, metallurgy, petroleum engineering, ceramics, and/or industrial engineering.

Students having a deficiency of 9 credits or fewer in this total of 51 may be admitted as regular graduate students but will be required to make up such deficiencies without the credits being applicable toward the advanced degree.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. The Metals and Their Ores (3)
484. The Solid Fuels (3)
486. Petroleum and Natural Gas Economics (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (2)

500. Advanced Principles of Mineral Economics (3-6) Economic history of mineral industries, research methods, economics of mineral exploitation and utilization, mineral policy.

501. Research in Mineral Economics (3-6) Investigation in specialized fields of research in mineral economics. Prerequisite: 3 credits in Mn.Ec. 500.

502. Technologic Influences (3-9) Relationship of technologic advancements to economic development of the mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

505. Problems of Mineral Economics (3-12) Determination of basic technologic-economic patterns of selected mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

MINERAL PREPARATION

David R. Mitchell, *Acting Head of the Department*
4 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Mitchell, Spicer, and Sun; Associate Professor Lovell.

Areas in which students may specialize include the fundamentals of gravity, electrical, and chemical methods of beneficiating natural mineral deposits. Graduate work may also be undertaken on the properties of specific minerals as they are related to beneficiation.

Graduates with a bachelor's degree in such scientific fields as chemistry, physics, and mathematics, and in such engineering fields as mining, metallurgy, ceramics, fuel technology, and mechanical, electrical, and civil engineering are eligible for admission. However, graduates in the above fields are required to take 6 credits of undergraduate courses in mineral preparation along with their graduate program.

MINERAL PREPARATION (MN PR)

401. Advanced Mineral Preparation Laboratory (1)
404. Plant Layout and Design (3)
410. Coal Preparation (3)
420. Unit Operations (3)
430. Flowsheets of Mineral Preparation Plants (3)
457. Field Trip (1-2)

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 420.
Mr. Sun

504. Mineral Preparation Research (1-6 per term) Research work on specific problems in mineral preparation. Prerequisite: Mn.Pr. 410 or 420.
Mr. Mitchell and Staff

505. Gravity Processes and Miscellaneous Methods of Mineral Preparation (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and dense-media processes of mineral concentration. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

506. Mineral Preparation Plant Design (3-10) Layout, design, and selection of equipment for specific mineral preparation plant projects. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

507. Chemical Processes of Mineral Preparation (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Mn.Pr. 420. *Mr. Lovell*

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineral preparation studies are listed under Mineral Sciences.*

MINERALOGY AND PETROLOGY

John C. Griffiths
Head of the Department of Geochemistry and Mineralogy
114 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bates, Brindley, Greig, Griffiths, Keith, Osborn, Roy, Tuttle, and Vand; Associate Professors Barnes, Burnham, Wright, and Wyllie; Assistant Professor Dachille; Mrs. Roy.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, mineralogy, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits of general physics; and 30 credits of geology, petrology, and mineralogy including microscopical petrography (i.e., an equivalent to G.Sc. 485, acceptable to the faculty). Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

MINERALOGY (MIN)

413. Scientific Method Applied to the Earth Sciences (3)
463. Optical Mineralogy (2) *Mr. Wright*
464. Optical Mineralogy (1) *Mr. Wright*
483. Petrology (2) *Mr. Wyllie*
484. Petrology (2) *Mr. Griffiths*
485. Petrology (2) *Mr. Wyllie*

500. Optical Crystallography of Minerals (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 464. *Mr. Wright*

501. Petrology (3-6) Microscopic study of rocks, emphasizing classification and genetic relationships. *Messrs. Krynine, Tuttle, Wyllie, and Griffiths*

502. Mineralogical Problems (3) Original study of some limited mineralogical or petrological problems.

504. Theoretical Mineralogy (3) Crystal chemistry and crystal physics applied to solid solution, polymorphism, crystal growth, and related phenomena. *Mr. Bates*

505. Mineralogy Seminar (1-2) Reading, presentation, and discussion of literature dealing with various phases of theoretical mineralogy. Topics are selected to meet the interests of the majority of the students. *Messrs. Krynine, Tuttle, Bates, Griffiths, Wright, Wyllie, Vand, and Brindley*

*510. Metamorphic Petrology (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484, 485. *Mr. Wyllie*

511. Sedimentary Petrology (3-4) Composition, texture, structure, mass properties of sediments; dynamic processes in complex natural systems; sedimentary stages: weathering, erosion, transport, deposition, lithification. Prerequisites: Min. 483, 484, 485. Concurrent: Min. 513. *Mr. Krynine*

512. Sedimentary Petrology, Continued (2-4) Diastrophism and tectonic background of sedimentation; depositional loci; classification of sediments: quartzites, graywackes, arkoses; chemical sediments; paleogeography, paleoclimatology, oil finding. Prerequisite: Min. 511. Concurrent: Min. 514. *Mr. Krynine*

513. Methods of Analysis of Sediments (3) Principles and practices used in analyzing sedimentary rocks for size, shape, and accessory (heavy) minerals. Concurrent: Min. 511. *Mr. Griffiths*

514. Applied Sedimentology (3) Design and control in analysis of sedimentary rocks; application of these techniques to industrial problems. Concurrent: Min. 512. *Mr. Griffiths*

520. Study of Accessory Minerals (2-4) Detailed study of accessory (heavy) minerals; their significance in problems of provenance, petrogenesis, mineral stratigraphy, and paleogeography. Prerequisites: Min. 511, 512, 513, 514. *Mr. Griffiths*

524. Introduction to Sedimentation (3) Prerequisites: Min. 483, 484. Concurrent: Min. 485. *Mr. Krynine*

525. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 485, 500, 527. *Messrs. Tuttle and Wyllie*

526. Statistical Problems in Sedimentary Geology (3) Application of experimental design, sampling procedures, multiple regression and discriminant analysis in solving problems in sedimentary petrography. Prerequisites: Min. 514; Math. 410 or Agro. 545. *Mr. Griffiths*

527. Igneous and Metamorphic Mineralogy (3) Structural and compositional variations of minerals in igneous and metamorphic rocks. *Mr. Jahns*

529. Radioactivity in Rocks (1-2) Distribution, mineralogy, and petrology of the radioactive elements. *Mr. Wright*

*Credits to be arranged, 2-4 per term.

530. (Cer.T. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments.
Messrs. Griffiths, Bates, and Brindley

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Mineral Sciences.*

MINING ENGINEERING

David R. Mitchell, *Acting Head of the Department of Mining*
305B Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Hartman, Kochanowsky, and Mitchell; Associate Professor Stefanko.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting), mechanization, and mine plant (unit operations, materials handling, continuous mining, power supply), development and exploitation methods (mine planning and layout, design of systems), mine management, production engineering and operations research (time study, standards, job rating, operations analysis), environmental control (gas and dust technology, ventilation, air conditioning, hygiene, illumination, safety), and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation).

A bachelor's degree in mining engineering or some related engineering field is required for admission to graduate work. Students may be required to make up deficiencies in their area of specialization. Certain basic, related courses outside the department may be approved as part of the major.

MINING (MNG)

402. Mine Power (3)
410. Mining Engineering Analysis (3)
411. Mine Systems Engineering (3)
412. Mine Management (2)
422. Mine Ventilation and Air Conditioning (3)
431. Rock Mechanics (3)
451-452. Advanced Mining Engineering I and II (1 each)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

525. Dust Technology (3) Physical and chemical properties of dusts; airborne dust determinations and analysis; dust control applicable to mills and mines. Prerequisite: Mng. 422.

526. Mine Ventilation (3) Airflow in mine openings and its control; network solution by mathematics and computer; design of mine and industrial ventilation systems. Prerequisite: Mng. 422.

528. Mine Air Conditioning (3) Thermodynamics of vapor mixtures; heat flow through rock; physiological effects of hot, humid environments; design of temperature-humidity control systems. Prerequisite: Mng. 422.

532. Rock Mechanics (3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence. Prerequisite: Mng. 431.

541. Theory of Rock Penetration (3) Behavior of rock under dynamic loads intended to penetrate; basic energy relations; application of theory to drilling and other penetration. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Graduate Mining Seminar (1 per term) Preparation and presentation of formal papers on problems of an advanced nature in mining engineering. Required once during each year of residence.

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mining studies are listed under Mineral Sciences.*

MUSIC

Hummel Fishburn, *Head of the Department*
Armory

Degree Conferred: M.A.
Graduate Faculty: Professors Fishburn, Henninger, Stevens, and Taylor; Associate Professors Ceiga, Karhan, and Raver; Assistant Professor Brinsmaid.

In his graduate program a student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, music literature, and creative music. The minor must be chosen from the liberal arts.

Admission requires completion of a recognized music curriculum.

A thesis is required of all M.A. candidates in this major.

MUSIC (MUSIC)

407. Piano Literature (3)
410. Music of the 20th Century (3)
411. A Chronological Study of String Literature (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
*429. Singer's Style and Interpretation (3) Fee $50.
456. Elementary Counterpoint (3)
459. Modern Instrumental Arranging (3)
466. Advanced Conducting (3)

*May be repeated for a total of 12 credits.

*503. Advanced Stringed Instruments (3) Study, repertoire building, and recital performance. Fee $50.

*511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $50.

*531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $60.

543. Modern Harmony (3) Harmonic writing based on 20th century practices with attention to traditional idioms that serve as foundation.

557. Symphonic Structure (3) Survey of the evolution and application of the forms used in symphony, sonata, concerto, string quartet, and related works. Prerequisite: Music 57.

*558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms. Prerequisite: 18 credits in harmony, counterpoint, and piano.

563. Free Arranging (3) Correct procedure in arranging for vocal and instrumental ensembles; practical exercises in quartets, glee clubs, and choruses; small instrumental groups, band, and orchestra. Prerequisite: 18 credits in harmony, including 3 of orchestration.

567. The Literature of the Orchestra (3) The suite, symphony, tone poem, and overture from the point of view of appreciation, form, and orchestration. Prerequisites: Music 6 and theoretical knowledge of the key instruments of the orchestra.

599. Music Seminar (1-3) Seminar in the history, art, and science of music, with readings, discussion, and performance.

MUSIC EDUCATION

Hummel Fishburn, *Head of the Department*
Armory

Degrees Conferred: D.Ed., M.Ed.
Graduate Faculty: Professors Andrews, Dunlop, and Fishburn; Associate Professors Campbell and Karhan.

A student majoring in music education is required to offer a minor in music. However, the master's program must include some work, and the doctoral program considerable work, in the area of general education.

Doctoral students may specialize in vocal, instrumental, or theoretical music in elementary, secondary, or college teaching; but the degree requires work in each of these fields.

For admission to a graduate program a student must have completed a recognized music education curriculum.

MUSIC EDUCATION (MU ED)

446. The Elementary Music Specialist (3)
462. Pedagogy of Theory (3)
468. The Teaching of Piano (3)
469. Band and Orchestra Technique (3)

*May be repeated for a total of 12 credits.

470. Choral Technique (3)
475. Objectives and Problems in Elementary Music Education (3)
480. Choral Program in the Secondary School (3)

500. Music Education Seminar (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

569. Present-Day Trends in Instrumental Music (3) New methods and materials for band, orchestra, and ensembles.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

573. The Materials of Appreciation (3) Methods and materials for development of music appreciation in elementary and secondary schools. Prerequisites: Music 5, teaching experience.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis upon practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

594. Pedagogy of Ear Training (3) Materials and methods for training the listener to grasp, understand, and write what is heard from melody to four-part harmony. Prerequisite: 12 credits in ear training and/or harmony.

NUCLEAR ENGINEERING

Nunzio J. Palladino, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.
Graduate Faculty: Professors Foderaro and Palladino; Associate Professors Diethorn, Jacobs, Kline, and Remick.

A student may specialize in reactor physics, neutron and radiation transport phenomena, thermal and mechanical design of reactors, nuclear materials, or reactor instrumentation and control. Admission requires a bachelor's degree in engineering or in the physical sciences. Students who have not had appropriate undergraduate courses in modern physics and differential equations will be required to schedule them.

NUCLEAR ENGINEERING (NUC E)

410. Nuclear Engineering (3)
411. Nuclear Engineering (3)
420. Radiological Safety (2)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 521.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 521.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

507. Interaction of Radiations with Matter (2) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisites: Phys. 406; 454 or 456.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521. Neutron Transport Theory (3) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

550. Special Topics in Nuclear Engineering (1-12) Theoretical studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 44, Phys. 406.

PHYSICAL SCIENCE (PH SC)

501. Seminar in Nuclear Science and Engineering (0)

PETROLEUM AND NATURAL GAS ENGINEERING

C. Drew Stahl
Head of the Department of Petroleum and Natural Gas
26 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Nielsen, Slobod, and Stahl; Associate Professors Bissey and Burcik.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

Students who expect to enter graduate study in this field with a degree in another curriculum should present 20 credits of chemistry and physics, 6 of geology, 15 of engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission.

Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

PETROLEUM AND NATURAL GAS (P N G)

410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
431. Drilling Fluids (2)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)

510. Flow of Homogeneous Fluids Through Porous Media (3) Concepts and mathematics describing steady and unsteady state flow in porous media for various initial and boundary conditions.

*512. Reservoir Engineering (3-6) Applications of the principles of fluid behavior in porous media to the analysis of complex reservoir behavior; log interpretation. Prerequisite: P.N.G. 510.

515. Secondary Recovery (3) Methods of predicting oil recovery by immiscible fluid injection.

517. Case Studies of Secondary Recovery (1-3) Interpretation and critical analysis of production and injection characteristics of typical water flood operations. Prerequisite: P.N.G. 515 or 485.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

525. Special Topics in Petroleum Engineering (2-6)

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycles; current developments. Prerequisite: P.N.G. 481.

†535. Seminar (1-3)

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Mineral Sciences.*

*Credits to be arranged, 3 per term.
†Credits to be arranged, 1 per term.

PHILOSOPHY

JOHN M. ANDERSON, *Head of the Department*
420 Boucke Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Anderson, Bugbee, Finch, Freund, Johnstone, and Mourant; Associate Professors Rosen and Tsugawa; Assistant Professors Gotshalk and Price; Mr. Whittier.

A student may concentrate on history of philosophy, logic and scientific methods, or value theory. The department may waive the requirement of a thesis for M.A. candidates in this major.

Undergraduate preparation should include a major in philosophy, but a strong minor may also be acceptable.

PHILOSOPHY (PHIL)

406. MEDIEVAL PHILOSOPHY (3)
410. STUDIES IN GREEK PHILOSOPHY (3-6)
411. STUDIES IN MODERN PHILOSOPHY (3-6)
412. STUDIES IN CONTEMPORARY PHILOSOPHY (3)
413. PHILOSOPHY OF LITERATURE (3)
414. AESTHETIC THEORY (3)
417. NINETEENTH CENTURY PHILOSOPHY (3)
419. PHILOSOPHICAL BACKGROUNDS OF AMERICAN THOUGHT (3)
420. PHILOSOPHY OF HISTORY (3)
421. CLASSICS OF SCIENTIFIC METHOD (3)
426. METAPHYSICS (3)
427. ADVANCED ETHICS (3)
428. (Math. 428) LOGICAL THEORY (3)
429. SEMANTICS: PHILOSOPHY OF LANGUAGE AND SYMBOLISM (3)
430. PHILOSOPHICAL PROBLEMS (3-6)
435. RELIGION AND SCIENCE (3)

500. ETHICS: HISTORICAL AND SYSTEMATIC (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. SOCIAL AND POLITICAL PHILOSOPHY (3) Critical study of basic problems in their historical and functional setting.

505. PHILOSOPHY OF WESTERN RELIGION (3) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. SEMINAR IN ANCIENT PHILOSOPHY (3-6) Study of one or more important men or movements in ancient philosophy.

507. SEMINAR IN MEDIEVAL PHILOSOPHY (3-6) Study of one or more important men or movements in medieval philosophy.

508. SEMINAR IN MODERN PHILOSOPHY (3-6) Men and movements in philosophy from the Renaissance through the 19th century.

509. SEMINAR IN CONTEMPORARY PHILOSOPHY (3-6) Men and movements in 20th century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in 19th Century Philosophy (3) Study of a philosopher or philosophical movement of the 19th century.

515. Philosophical Method (3) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (3-6) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550-551. (Math. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. (Math.) 428.

554. (Math. 554) Metamathematics (3) Prooftheoretic and modeltheoretic study of systems: Gödel's theorem, relative and absolute consistency proofs, decidability, properties of relational structures, mathematical applications. Prerequisite: Phil. (Math.) 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; recursive and recursively enumerable sets; equivalent formulations of computability; Church's thesis; related topics from current literature. Prerequisite: Phil. (Math.) 428.

PHYSICAL EDUCATION

John D. Lawther
Associate Dean of the College of Health and Physical Education
246 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Buskirk, Conger, Coombs, Gross, Harnett, Lawther, Speidel, and Thiel; Associate Professors Lucey and Magnusson.

Emphasis may be placed on health education, physical education, or receation education.

In health and physical education, areas of specialization include: (1) history, philosophy, and principles; (2) applied science (physiology of exercise, kinesiology, body mechanics); (3) organization and administration; (4) objectives, programs, methods, and evaluation; (5) adaptives and correctives; (6) health content; and (7) athletics, intramural and interschool. The master's candidate is expected to acquire a basic minimum of knowledge in each of these areas with little specialization except for his thesis or problem. The doctoral candidate is expected to focus on one area during his final year of graduate work.

The requirements for admission to the M.Ed. program are 24 credits in professional health and physical education and 24 in education and psychology, including general psychology, educational psychology, principles and methods of teaching, education electives, and practice teaching.

The requirements for admission to the M.S. program are 36 credits in professional health and physical education and 18 in education and psychology. An excellent background in the biological and physical sciences may satisfy up to half of the requirement in professional health and physical education. Biological science majors, with appropriate course selection, may qualify for the health education option.

In the recreation option, students may prepare for park and recreation administrative positions in municipal, state, or federal agencies; semipublic or private agencies; hospitals or industries; or for leadership of special groups in a particular activity. The areas for specialization include: (1) history, philosophy, and principles; (2) administration and supervision; (3) planning park areas and facilities; (4) program content and application; (5) surveys and appraisals; (6) public administration; and (7) research.

To qualify for the recreation option, an undergraduate major in recreation education is desirable; but a major in sociology, music, physical education, fine or industrial arts, theatre arts, or other related fields may be accepted.

Students who lack some of the prerequisite courses may be admitted but are required to make up the deficiency without degree credit.

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)

501. Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

505. Advanced Techniques in Health Education (3) Prerequisites: Hl.Ed. 215, Psy. 437.

572. Tests and Measurements in Health Education (3) Critical study, evaluation, and demonstration of tests and measures of health education; statistical computations of data. Prerequisites: Ph.Ed. 490, Hl.Ed. 215.

PHYSICAL EDUCATION (PH ED)

452. Analysis of Physical Education Activities for the Elementary School (3)
454. The Natural Program of Physical Education Activities, Applied (3)
455. Scientific Method in Health and Physical Education (3)
460. Methods and Principles of Athletic Coaching (3)
480. Advanced Anatomy and Physiology, Applied (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)

500. Problem in Physical Education (3) Prerequisite: Ph.Ed. 455.

522. Organization and Administration of Physical Education in Colleges and Universities (3) Administration of physical education in college; credits, schedules, excuses, records, reports, budgets, classification, tests, staff, and facilities. Prerequisite: Ph.Ed. 491.

523. Administration of College Athletics (3) Eligibility, schedules, man-

agerial systems, relationships of athletics to the physical education program and to education in general. Prerequisite: Ph.Ed. 491.

526. Athletic Problems in Schools (3) Practical problems which result from administration of athletics in schools. Reports on some aspects of athletics required. Prerequisite: Ph.Ed. 460.

528. Professional Education of Teachers of Health and Physical Education (3) Health and physical education surveys, publicity, sociability and personality tests, legislation, state certification, standards for facilities and equipment, in-service, follow-up, and teacher-community problems. Prerequisite: Ph.Ed. 491.

529. Supervision of Physical Education in Schools (3) Methods and policies of the school supervisor of physical education; conferences, planning and presenting the program, evaluating results, improving teachers-in-service, supervision of the classroom teacher. Prerequisite: Ph.Ed. 491.

530. Research Techniques in Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 490.

531. Research in Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction. Prerequisite: Ph.Ed. 454.

535. Modern Foreign Systems of Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

536. Scientific Methods in Athletic Coaching (3) Unusual techniques in athletic coaching which are not commonly recognized and used; advanced skills and strategy in coaching major sports. Prerequisite: Ph.Ed. 460.

550. Seminar in Health and Physical Education and Recreation Education (1-6)

555. Relationships of Physical Education to the Exact Sciences (3)

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education into the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

581. Problems in Body Mechanics (3) Certain aspects of human motion and body segmental alignment; analysis of human gait, and the dynamic adaptation of the spine, thorax, and pelvis to external physical forces. Prerequisites: Hl.Ed. 244, Ph.Ed. 399.

595. Philosophy of Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 491 or Rc.Ed. 465.

RECREATION EDUCATION (RC ED)

430. Camping and Outdoor Education (3)

434. (L.Arch. 434) Recreation Areas and Facilities (3)
456. Social Recreation (3)
461. Community Recreation (3)
465. Administration of Recreation (3)

530. Camp Administration (3) Camp site development; staff selection, training, and supervision; development of objectives and program planning; values inherent in outdoor and camping education. Prerequisite: Rc.Ed. 430.

533. Recreation Studies, Surveys, and Appraisals (3) Types, purposes, and methods of conducting recreation studies and surveys; procedures in appraisal of community recreation. Prerequisite: Ph.Ed. 530.

560. Administrative Problems of Recreation (3) Administrative problems in park and recreation departments; departmental organization, finance, personnel, facilities, program, and public relations. Prerequisite: Rc.Ed. 465.

PHYSICAL SCIENCE

Henry W. Knerr
Chairman of the Committee on Physical Science
101 Willard Building

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, includes at least 24 credits in physical science chosen from chemistry, earth sciences, mathematics, and physics and a minor of at least 6 credits in educational foundations. A candidate is required to earn at least 15 credits in chemistry and physics with a minimum of 6 in each, and at least 3 credits each in earth sciences and mathematics. The completion of a satisfactory term paper and a course in integral calculus is also required.

For admission to the M.Ed. program a student is expected to have completed at least one year each in college chemistry and college physics, mathematics through trigonometry, and 18 credits in education and related psychology. For admission to the D.Ed. program a course in integral calculus is also required.

The D.Ed. program requires a minimum of 60 credits in physical science of which 24 may be in courses designed specifically for teachers. At least 12 credits each in chemistry and physics must be selected from standard courses at the 400 and 500 level. A minimum of 15 credits each is required in professional education and thesis research. The thesis may be based on an experimental study in chemistry or physics or on the study of a problem in the teaching of physical science.

See also "Earth Sciences," "Chemistry," "Mathematics," and "Physics."

PHYSICS

John J. Gibbons, *Acting Head of the Department*
101 Osmond Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Professors Brickwedde, Gibbons, Knerr, Müller, Pollard, Pratt, Rank, Schilling, Webb, and Wiggins; Associate Professors Bauer, Burnett, Cutler, Ginoza, Goldburg, Kazes, McCubbin, McKelvey, Schraer, Signell, Strother, Weber, Winter, and Work; Assistant Professors McCammon, Person, Thwaites, and Yahia.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, crystal structure, solid state, field emission, acoustics, high-pressure physics, biophysics, plasma physics and shock waves, low-temperature physics, nuclear physics, physics of high polymers, and various phases of theoretical physics.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed 18 credits in college physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including Phys. 400 and 458 and approved laboratory work such as Phys. 470; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics (4)
404. Electronic Measurements (2-4)
406. Nuclear Physics (3)
411. Theoretical Mechanics (3)
412. Introduction to Solid State Physics (3)
417. The Teaching of Physics (3)
420. Intermediate Heat (3)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
436. Optics for Teachers (3)
437. Heat, Wave Motion, and Sound for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
441. Demonstration Experiments for Teachers (3)
443. Intermediate Acoustics (3)
444. Measurements in Acoustics (2)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2)
458. Intermediate Optics (4)
461. Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)
473-474. Biophysics (3 each)
477. X-ray Analysis of Solids and Liquids (3)

507. Thermodynamics and Kinetic Theory (3) Classical and modern thermodynamics; introduction to statistical mechanics.

509. Physics Seminar (1-3 per term) Topics from current research.

512-513. Solid State Physics (3 each) Analytical treatment of physical properties of solids: crystal structure, X-ray diffraction, lattice vibrations, paramagnetism, ferromagnetism, ferroelectricity; electron theory of metals, semiconductors. Prerequisite: Phys. 530.

517. Statistical Mechanics (3) Classical and quantum statistics, theory of ensembles, degenerate gases, applications to low temperature effects and cooperative phenomena. Prerequisites: Phys. 507, 561.

521. Crystal Structure (3) Crystal symmetry, X-ray scattering, theory and techniques of crystal structure determination.

522. Advanced Crystal Analysis (3) Phase-determining methods in crystal analysis.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle; canonical transformation; Lagrange and Poisson brackets; Hamilton-Jacobi equations; classical theory of fields. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and visco-elastic media. Prerequisite: Phys. 530.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

560. Research Problems (1-18) Introduction to research through individual assignments.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

572. Selected Topics in Spectroscopy (3) Atomic and molecular spectra, experimental methods and theoretical analyses.

575. Special Topics (1-3 per term) Theoretical studies in any field of modern physics with or without associated experimental work. Prerequisite: Phys. 456.

PLANT PATHOLOGY

James Tammen
Acting Head of the Department of Agricultural Plant Pathology
206 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Kneebone, Lewis, Mills, and Wernham; Associate Professors Bloom, Boyle, Couch, Graham, and Tammen; Assistant Professor Wood.

A student may specialize in the study of plant diseases caused by fungi, bacteria, or viruses, and/or in their control, especially by plant breeding or by chemical means.

For admission a student must present at least 27 credits in botany, plant pathology, and biological science, of which not more than 6 may be in biological science. As

many as 6 credits may be made up as undergraduate deficiencies after the candidate has been admitted to the Graduate School.

See also "Botany" and "Genetics."

PLANT PATHOLOGY (P PATH)

404. Diseases of Field and Forage Crops (3) *Mr. Couch*
408. Plant Pathological Techniques (3) *Mr. Bloom*
412. Advanced Forest Pathology (3) *Mr. Wood*
425. Diseases of Ornamental and Floricultural Plants (3) *Mr. Tammen*
428. Diseases of Fruit and Vegetable Crops (3) *Messrs. Bloom and Boyle*

501. Clinical Plant Pathology (3) Advanced course in diagnostic techniques to acquaint the students with specialized procedures for field and laboratory identification of plant diseases. Prerequisites: P.Path. 10, 408, Bot. 419. Summer term only. *Mr. Couch*

509. Principles of Plant Infection (3) Physiological processes of plant pathogenic bacteria and fungi occurring during incubation, ingress, and infection. Prerequisites: P.Path. 10 or 11, Bot. 419. Winter term, odd years. *Mr. Tammen*

515. Disease Resistance in Plants (2-4) Stability of resistance, selection of resistant material, economics of control, special problems. Prerequisites: Bot. (Zool.) 22 or 33, P.Path. 10. Fall term, odd years. *Messrs. Wernham and Mills*

518. Special Problems (1-12) The prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Virus Diseases of Plants (3) Nature, symptomatology, transmission, and control of virus diseases of plants. Fall term, even years. *Mr. Boyle*

520. Plant Pathogenic Bacteria (3) Bacteria causing plant diseases; methods of identification, inoculation, and control. Spring term, odd years. *Mr. Kneebone*

530. Plant Disease Control (3) Methods, and laboratory and field testing of materials used in plant disease control. Spring term, even years.

531. Plant Pathology Seminar (1 per term) Selected topics of current rsearch, history, and contemporary trends in plant pathology.

POLITICAL SCIENCE

John H. Ferguson, *Head of the Department*
129 Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Professors Aspaturian, Atwater, Brewster, Ferguson, McGeary, Riemer, and Silva; Associate Professors Beasley, Monat, and Thurber; Assistant Professor Albinski.

Students may specialize in American government, public administration, political theory, international relations, or comparative government.

Applicants for admission to the M.A. and Ph.D. programs will be expected to have at least 12 credits in political science or its equivalent. In exceptional cases students may be permitted to make up deficiencies after beginning their graduate programs.

The department may waive the requirement of a thesis for M.A. candidates in this major.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Mr. Masters*
411. American Political Theory (3) *Messrs. Hobbs and Riemer*
413. Government and Politics of the Soviet Union (3) *Mr. Atwater*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*
415. International Organization (3-6) *Messrs. Aspaturian and Atwater*
416. International Law (3) *Mr. Aspaturian*
417. American Local Government and Administration (3) *Mr. LeDuc*
419. Public Administration (3) *Mr. Monat*
421. Modern Political Theory (3) *Mr. Riemer*
426. Political Parties (3) *Miss Silva*
427. Political Opinion and Propaganda (3) *Miss Silva*
431. Ancient and Medieval Political Theories (3) *Messrs. Hobbs and Riemer*
432. Current Political Trends and Problems in the United States (3-9)
433. The Law of Labor-Management Relations (3) *Mr. Brewster*
442. American Foreign Policy (3) *Mr. Atwater*
444. Government Regulation (3) *Mr. Beasley*
445. Administrative Law (3) *Mr. Brewster*
447. Constitutional Law: The Federal System (3) *Miss Silva*
448. Constitutional Law: Government and the Individual (3) *Mr. Brewster*
450. Governments and Foreign Policies of the Commonwealth of Nations (3) *Mr. Albinski*
451. Comparative Political Systems (3) *Mr. Albinski*
456. Governments and Foreign Policies of Latin America (3)
458. Governments and Foreign Policies of the Far East (3-6)
499. Foreign Study in Government (2-6)

500. Seminar in Political Science (3-12) Subject to be announced. *Mr. Brewster*

505. Seminar in Advanced American Government (3-12) *Miss Silva*

509. Research Techniques in Political Science (3) *Mr. Ferguson and Staff*

512. Comparative Government (3-12) *Mr. Albinski*

515. International Relations (3-6) *Messrs. Aspaturian and Atwater*

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

519. Public Administration (3-6)

521. Political Theory (3-6) *Mr. Riemer*

535. Government Regulation (3-6)

570. Current Trends and Problems in Administration (3-6) *Mr. Ferguson*

571. Theory of Public Management (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Monat*

572. International Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. Thurber*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. Thurber*

575. Public Personnel Administration (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline. *Mr. Beasley*

576. Public Fiscal Administration (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *Mr. Monat*

577. Public Organization and Methods (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Ferguson*

578. Public Planning and Zoning (3) Public planning agencies and their functions; essentials of effective planning and zoning; current trends and problems.

580. Internship in Public Administration (6)

POULTRY SCIENCE

Arthur J. G. Maw, *Head of the Department*
103 Weaver Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bressler, Hale, Maw, and Murphy; Associate Professors Buss, Mueller, and Schein.

Students may specialize in poultry nutrition, poultry management, poultry products, poultry breeding, or animal behavior. In each area the program consists of a joint major between the Department of Poultry Science and one or more basic science departments. Admission requirements vary according to the area of specialization. Students with undergraduate majors in the basic sciences may qualify.

Excellent facilities are available for research in production, processing, and preservation of market eggs and dressed poultry, and in chick and poult nutrition. A specially designed and equipped Solar Laying House also provides facilities for investigation of production and behavioral problems encountered in large, concentrated populations of layers.

POULTRY SCIENCE (PTY SC)

401. (Psy. 401, Zool. 401) Animal Behavior (3) *Mr. Hale*
402. Special Topics (3-12)

502. Advanced Poultry Nutrition (2-4) *Mr. Murphy*

503. Advanced Poultry Farm Management (2-4) *Mr. Bressler*

504. Advanced Market Poultry and Eggs (2-4) Prerequisites: Pty.Sc. 1, 7; Ag.Ec. 33 or 2 additional credits in poultry science. *Mr. Mueller*

505. Research in Poultry Science (1-10 per term) Prerequisite: 9 credits in poultry science.

506. Seminar in Poultry Science (1-6)

582. (Psy. 582, Zool. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale and Schein*

PSYCHOLOGY

Dale B. Harris, *Head of the Department*
101 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.S.
Graduate Faculty: Professors Adams, Bernreuter, Carpenter, Hale, Guest, Guthrie, Hall, Harris, Lepley, Mitzel, Smith, and VanOrmer; Associate Professors Gorlow, Hoffman, Palermo, Piers, Prokasy, Schipper, Thevaos, Warren, and Whaley; Assistant Professors Hartman and Singer.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, measurement and statistics, social and personality, developmental, clinical, school, industrial and business, engineering and human factors.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computer Center, the Laboratory for Physiological and Comparative Psychology, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a junior-senior scholastic average of B, a minimum of 12 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test. Applicants with a master's degree will have their admission evaluated with emphasis on the quality of their graduate program.

PSYCHOLOGY (PSY)

400.	Honors Course in Psychology (2-6)	
401.	(Pty.Sc. 401, Zool. 401) Animal Behavior (3)	*Mr. Hale*
402.	Sensation and Perception (3)	*Mr. Freeman*
403.	Introductory Physiological Psychology (3)	*Mr. Warren*
404.	Learning and Motivation (3)	
405.	The Experimental Psychology of Visual Perception (3)	*Mr. Leibowitz*
410.	History of Psychology (3)	*Mr. Leibowitz*
412.	Abnormal Psychology (3)	*Mr. Guthrie*
415.	Intermediate Statistics in Psychology and Education (3)	*Mr. Prokasy*
417.	Social Psychology (2-3)	*Mr. Singer*
418.	Measurement of Personality (3)	
419.	Guidance and Education in Sexual and Marital Adjustment (3)	*Mr. Adams*
422.	Psychological Methods of Measuring the Reactions of the Public (3)	*Mr. Guest*
425.	Psychology of the Elementary School Child (2-3)	*Mr. Whaley*
426.	Adolescence (2-3)	*Mr. Harris*
427.	Psychological Principles in Advertising (3)	*Mr. Guest*
428.	Opinion Research Laboratory (3)	*Mr. Guest*
431.	Industrial Psychology (3)	*Mr. Smith*
432.	Introductory Engineering Psychology (3)	*Mr. Schipper*
433.	Psychology of Occupational Behavior (2)	
436.	Mental Hygiene in Schools (3)	
437.	Psychology of Adjustment (3)	*Mr. Gorlow*
438.	Theory of Personality (3)	*Mr. Guthrie*
440.	Psychology Projects (1-6)	
441.	Industrial Motivation and Morale (3)	
445.	(C.D.F.R. 445) Development Throughout Adulthood (3)	*Mr. Britton*
450.	(Ed.Psy. 450) Measurement of Abilities (3)	

474. Psychology of Exceptional Children (3) *Miss Piers*
482. Introduction to Clinical Psychology (3) *Mr. Lundy*

500. Seminar: Introduction to Graduate Study (0) For all new graduate students in psychology.

501. Advanced Psychology (3) Comprehensive study of general psychology. Prerequisite: 9 credits in psychology. *Mr. Lepley*

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology. *Mr. Warren*

504. Comparative Psychology (2-4) Behavior from standpoint of phylogenetic growth and development; biological implications; comparison of different types of animals, including man. Prerequisite: 9 credits in psychology. *Mr. Warren*

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Advanced Theory of Learning and Habit Formation (2-3) Critical evaluation of major theories of learning: Hull, Guthrie, Tolman, Lewin; application of learning theory to major problems in psychology. Prerequisite: Psy. 404 or Ed.Psy. 414.

511. Seminar in Contemporary American Psychology (2-3) Current systems or schools of psychology with comparative study and critical analysis; points of view as presented by recognized leaders. Prerequisite: 9 credits in psychology. *Mr. Hall*

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 590.

516. Theories of Decision-Making (3) Theoretical models and experimental evidence concerning choice behavior, strategies, and values, under riskless conditions and under uncertainty and risk.

517. Psychology of Attitudes and Opinions (3) Acquisition and control of attitudes and opinions, including beliefs, convictions, biases, prejudices, and ideologies as determinants of action. Prerequisite: 18 credits in psychology, including Psy. 417, 422, 437.

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

522. Survey Research Techniques (3) Sample and questionnaire designs for investigation of consumer reactions and social issues, and appropriate analytic procedures. Prerequisite: 3 credits in statistics. *Mr. Guest*

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 590.

528. Opinion Research Administration (3-6) Practicum in planning, development of techniques, and administration of the sample survey. Prerequisites: Psy. 15, 21, 422. *Mr. Guest*

529. (C.D.F.R. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisite: 6 credits in child development or 6 in educational or child psychology, plus 3 in statistics.

534. Advanced Engineering Psychology (3) Experimental studies of psychological factors affecting design and operation of machines. Prerequisites: Psy. 402, 404; or Psy. 432 or 501.

535. Human Development (2-3) Psychological phases of human development throughout the life span; implications for school, community, and home. Prerequisite: 9 credits in psychology.

536. (C.D.F.R. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

537. Seminar in Industrial Psychology (3) Prerequisite: Psy. 431. *Mr. Smith*

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 414. *Mr. Smith*

539. Motivation and Emotion (3) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives. Prerequisite: Psy. 503. *Mr. Hall*

540. Seminar in Clinical Problems (1-6) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality and relevant research with emphasis upon normal processes. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisites: Psy. 412, 541.

543. Survey of Counseling and Psychotherapy (3) Critical analysis of important systems of counseling and psychotherapy; history, rationale, and method. Prerequisite: Psy. 541.

549. (C.D.F.R. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

551. Theory and Practicum in Clinical Appraisal of Abilities and Intelligence I (3-4) Theories of intellectual behavior; introduction to clinical testing with emphasis on individual intelligence tests. Prerequisites: Psy. (Ed.Psy.) 450, Psy. 482; or 15 credits in psychology. *Miss Piers*

552. Theory and Practicum in Clinical Appraisal of Abilities and Intelligence II (3) Theory, development of tests, and research in intellectual assessment; practicum experience with institutionalized subjects. Prerequisite: Psy. 551. *Miss Piers*

553. Advanced Theory of Clinical Assessment (3) Problems in clinical assessment of cognitive functioning, such as assessment of brain injury, aphasic behaviors, etc. Prerequisites: Psy. 542, 552.

555. Theory and Practicum in Clinical Assessment of Personality (3) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of projective methods. Prerequisites: Psy. 542, 552.

556. Theory and Practicum in Clinical Assessment of Pathological Syndromes (3) Current research and theoretical issues in the clinical assessment of pathological syndromes; includes practicum. Prerequisite: Psy. 555. *Mr. Guthrie*

557. Advanced Personality Assessment (3) Personality and measurement

theories related to problems of prediction, diagnosis, and research. Prerequisite: Psy. 556.

560. Practicum in Clinical Methods (3-6) Personality and vocational diagnostic evaluations and short-term counseling with adults and children. Prerequisites: Psy. 482, 541, 551.

561. Clinical Practicum with Children (1-3) Diagnosis and counseling of child-parent problems of learning and adjustment; includes principles of school psychology. Prerequisite: Psy. 560. *Miss Piers*

564. Theory and Practicum in Counseling and Psychotherapy with Adults (3-6) Counseling with personal adjustment problems referred to the Psychology Clinic. Prerequisites: Psy. 543, 560. *Mr. Lundy*

567. Theory and Practicum in Counseling and Psychotherapy with Children (1-3) Practical experience in the Psychology Clinic in use of play therapy with young children; staff meetings; seminar on principles and techniques. Prerequisites: Psy. 543, 560, 564. *Miss Piers*

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-6) Practical experience in the Psychology Clinic in advanced nondirective therapy techniques; staff meetings; case conferences. Prerequisite: Psy. 564.

571. Social Psychology (3) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research. Prerequisite: 3 credits in social psychology.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

582. (Pty.Sc. 582, Zool. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale, Schein, and Warren*

590. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

EDUCATIONAL PSYCHOLOGY—A new Department of Educational Psychology has been established with H. E. Mitzel as acting head. Until a separate major in this field has been approved by the Graduate Faculty, however, students wishing to specialize in educational psychology should continue to apply for admission to the major field of psychology. They will be advised by one of the several faculty members who hold joint appointments in psychology and education (Professors VanOrmer, Mitzel, Thevaos, Lathrop, or Hartman).

EDUCATIONAL PSYCHOLOGY (ED PSY)

414. Intermediate Educational Psychology (2-3) *Miss Snyder*
423. Test Construction and Standardization (2-3)
435. Visual and Other Sensory Aids for Teachers (1-3)
436. Preparation of Educational Still Pictures (2-3)
437. Scripting and Shooting Educational Motion Pictures (2-3)
438. Editing and Sound Recording in the Production of Educational Motion Pictures (2-3)
442. Motion Pictures in Education (2-3)
443. Radio and Television in Education (3)

444. Still Pictures (1-2)
445. Advanced Audio-Visual Equipment (3)
450. (Psy. 450) Measurement of Abilities (3)
490. Educational Statistics and Measurements (2-3)
494. Educational Testing Programs (3)

502. Advanced Educational Psychology (2-4) Psychological theories and principles underlying educational theories and practices. Prerequisites: Ed.Psy. 14 or 414; practice teaching or teaching experience.

513. Educational Psychology: Differential (3) Causes of differences in achievement and personality; psychological implications of methods used by schools in adjusting to individual differences. Prerequisites: Ed.Psy. 14 or 414; 6 credits at 400 level in psychology.

514. Educational Psychology: Learning (2) Experimentally determined facts about the learning process; synthesis of main theories of learning; application of principles related to motivation, practice, retention, transfer, meaning, and problem-solving. Prerequisites: Ed.Psy. 14 or 414; 6 credits at 400 level in psychology or educational psychology.

535. Seminar in Curriculum Materials and Their Utilization (3) Advanced detailed analysis of mass communication media; relationships among these and educational objectives, individual differences in learners, and ideas to be communicated. Prerequisites: Ed.Psy. 435, Sec.Ed. 585, 6 credits in educational psychology.

540. Internship in Audio-Visual Education (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

541. Laboratory in Organizational Aspects of Materials of Instruction (1-3) Organizing, storing, circulating, and maintaining instructional materials in an instructional materials library. Prerequisites: Ed.Psy. 435, Sec.Ed. 585.

590. Advanced Educational Statistics (2-4) Appropriate measures and devices for experimental research in education including correlation measures, curve fitting, and analysis of variance. Prerequisite: 12 credits of graduate work in education including Ed.Psy. 490 or Psy. 415.

595. Introduction to the Advanced Study of Education (1-3) Methods of educational research; criticism of studies and theses in education; initiating research projects; summarizing results of research. Prerequisite: Ed.Psy. 490 or Psy. 415.

PUBLIC ADMINISTRATION

John H. Ferguson
Head of the Department of Political Science
129 Sparks Building

Degree Conferred: M.P.A.
Graduate Faculty: Professors Brewster, Ferguson, and Silva; Associate Professors Beasley, Monat, and Thurber.

All candidates will take a core program and specialize in one of the following options: general public administration, public planning administration, international administration, or city management.

Candidates must present for admission, or make up without graduate credit, at least 6 credits in political science and at least 3 credits in each of the following fields: economics, public finance, accounting or statistics, and psychology.

ROMANCE LANGUAGES AND LITERATURES

Lois Boe Hyslop
Acting Head of the Department of French
210 Sparks Building
or
H. Tracy Sturcken
Acting Head of the Department of Spanish, Italian, and Portuguese
212 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Belasco, Chapman, Eyer, Hyslop, and LeSage; Associate Professors Bleznick, Brentin, Moser, and Sturcken; Assistant Professor Triolo.

The minimum requirement for admission to an advanced degree program will normally be 24 credits of post-intermediate work in language and literature. A student concentrating in either French or Spanish may, if he wishes, choose the second area as a minor.

A thesis is required of all M.A. candidates in this major.

FRENCH (FR)

400. French Literature of the Renaissance (3)
405. French Literature in the Romantic Period (3)
406. French Literature in the Realistic Period (3)
411. French Prose of the 20th Century (3)
413. Contemporary French Drama (3)
416. French Poetry and Drama of the 20th Century (3)
421. The Teaching of Romance Languages (3)
431. French Literature of the Classical Period (3)
433. The Age of Enlightenment (3)
*450. French Institute (7-14)
471. Problems in French Literature (3-6)
490. Advanced Composition and Conversation (3)

†1G. Elementary French for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

501. French Drama of the Classical Period (3) Origins and development of French classical comedy and tragedy, emphasizing the works of Corneille, Racine, and Moliére.

549. Symbolism (3) The anti-positivistic tradition in 19th century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

552. Medieval French Literature (3) Familiarizes the student with Old and Middle French texts from the earliest monuments to Villon. Prerequisite: R.Ph. 551.

562. French Thinkers of the 18th Century (3)

*A maximum of 7 credits in one summer.
†No graduate credit is given for this course.

570. Voltaire and Rousseau (3)

571. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

580. Proust and Gide (3)

ITALIAN (IT)

571. Seminar in Italian Literature (3-6) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

PORTUGUESE (PORT)

571. Seminar in Portuguese Literature (3-6)

SPANISH (SPAN)

401. The Golden Age (3)
402. Drama of the Golden Age (3)
403. Don Quixote (3)
404. Old Spanish Language and Literature (3)
405. Spanish Drama of the 19th Century (3)
407. The Spanish Novel of the 19th Century (3)
408. The Contemporary Spanish Novel (3)
409. Introduction to Latin-American Literature (3)
410. Introduction to Latin-American Literature (3)
417. Spanish Literature in the Romantic Period (3)
421. The Teaching of Romance Languages (3)
*450. Spanish Institute (7-14)
471. Problems in Spanish Literature (3-6)
490. Advanced Composition and Conversation (3)

†1G. Elementary Spanish for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

501. Golden Age Literature (3) Nature and development of Spanish literature of the 16th and 17th centuries.

538. The Generation of 1898 (3) Principal works and intellectual trends of the period with special emphasis on Unamuno.

549. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío.

552. Medieval Spanish Literature (3) Familiarizes the student with Old Spanish texts.

565. Lope de Vega (3)

567. Cervantes and His Works (3)

571. Seminar in Spanish Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

*A maximum of 7 credits in one summer.
†No graduate credit is given for this course.

ROMANCE LITERATURE (R LIT)

544. Neoclassicism in the Romance Literatures (3) The neoclassical movement in the Romance literatures, with emphasis on French and Spanish.

545. Romanticism in the Romance Literatures (3) The Romantic movement in the Romance literatures, with emphasis on French and Spanish.

546. Medieval Romance Literatures (3) Medieval writings in the Romance literatures, with emphasis on French and Spanish.

547. Realism in the Romance Literatures (3) The Realistic movement in the Romance literatures, with emphasis on French and Spanish.

554. The Renaissance in the Romance Literatures (3) The effect of the Renaissance on the Romance literatures, with emphasis on French and Spanish.

ROMANCE PHILOLOGY (R PH)

551. Romance Philology (3)

558. Advanced Linguistics and Phonetics of the Romance Languages (3)

573. Theory and Techniques of Teaching the Romance Languages (1-2)

574. Methods and Bibliography in Romance Languages and Literatures (1-2)

RURAL SOCIOLOGY

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Bonser, Brown, and John; Associate Professors Bylund, Copp, and Fliegel; Assistant Professor Bealer.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at this University during the early part of his master's program.

RURAL SOCIOLOGY (R SOC)

402. Consumer Behavior and the Agricultural Industry (3) *Mr. Bylund*
452. Rural Organization (3) *Mr. Copp*
459. Rural Social Psychology (3)

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology. *Mr. Bealer*

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems. *Mr. Bealer*

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems. *Mr. Goldsmith*

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452. *Mr. Copp*

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior. *Mr. Bylund*

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system with emphasis on techniques of organization and program development. *Mr. Brown*

516. Change in Rural Society (2) Social change in rural society emphasizing prediction and control of the change process. *Mr. Fliegel*

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING

Benjamin A. Whisler
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.
Graduate Faculty: Professors Kountz and Whisler; Associate Professor Nesbitt.

The entering student should be a graduate in sanitary engineering from an accredited college of engineering, but a graduate in civil engineering may obtain the M.S. in sanitary engineering by taking a limited amount of extra undergraduate work in subjects appropriate to the sanitary engineering field. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.
See also "Civil Engineering."

SECONDARY EDUCATION

Herbert A. Smith, *Head of the Department*
168 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors McGarey, Patrick, Remaley, and Smith; Associate Professors Fagan, Fowler, and Kozak.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists.

In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are encouraged to have had at least two years of successful teaching experience.

Although candidates are required to specialize in secondary education, they are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned, in general, in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. Thus, for example, the M.Ed. degree may be earned with a major in English or chemistry. These programs require an approved minor in educational foundations.

SECONDARY EDUCATION (SEC ED)

400. Modern Trends in the Direction of Learning Experiences (3)
426. Teaching Mathematics in the Secondary Schools (4)
433. Teaching Social Studies in the Secondary Schools (4)
436. Teaching of Conservation of Natural Resources in the Secondary School (3)
437. Teaching of Conservation of Natural Resources in the Secondary School (3)
438. Teaching Science in the Secondary Schools (4)
443. Reading Problems in the Secondary School (2-3)
445. (El.Ed. 445) Techniques in Remedial Reading (2-6)
451. Secondary Education in America (3)
453. Teaching English in the Secondary Schools (4)
454. Extracurricular Activities in the Junior and Senior High School (2-3)
456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)
466. Teaching of Office Practice (3)
468. Teaching of Typewriting (2-3)
472. Measurement of Achievement in the Secondary School (2-3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

511. Internship in Business Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 490, and teaching experience.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisite: teaching experience and 18 credits in education, including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Bot. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec.Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. (El.Ed. 546) Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (1-4) Historical, psychological, social, and economic factors influencing secondary education; required as basic course of all graduate students in secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

556. (El.Ed. 556) Reading Clinic Practice: Analysis of Reading Disabilities (3-6) Analysis of extreme reading disabilities and recommended procedures; experience in preparation of case reports. Prerequisite: Sec.Ed. (El.Ed.) 445 or El.Ed. 444.

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Sec.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Sec. Ed. 577.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems in Secondary Education (1-6) For administrators, supervisors, experienced secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

SLAVIC LANGUAGES AND LITERATURES

Thomas F. Magner, *Head of the Department of Slavic Languages*
120 Sparks Building

Degree Conferred: M.A.
Graduate Faculty: Professors Folejewski and Magner; Assistant Professor Birkenmayer.

Programs leading to the master's degree in this field offer opportunities for specialization in literature or linguistics. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.
A thesis is required of all M.A. candidates in this major.

RUSSIAN (RUS)

426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)
450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)

*1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

501. Readings in Russian Literature (3-6) Prerequisite: Rus. 4.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

SLAVIC (SLAV)

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

*No graduate credit is given for this course.

SOCIAL STUDIES

Neil A. McNall
Chairman of the Committee on Social Studies
114 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

SOCIOLOGY

Macklin E. John
Head of the Department of Sociology and Anthropology
239 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Bernard, Clark, Foreman, John, Mather, F. R. Matson, and Mook; Associate Professors Baker, Dansereau, Dupree, M. B. Matson, Sanders, and Theodorson.

Undergraduate preparation must include 12 credits in sociology and at least 7 in other social sciences, with a broad background in the arts and sciences preferred. Students of exceptional ability who are slightly deficient in undergraduate preparation may be accepted, on condition that they make up their deficiency in courses without degree credit.

A thesis is required of all M.A. candidates in this major.

SOCIOLOGY (SOC)

400. Sociological Principles (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)
408. Social Ecology (3)
413. Methods and Techniques of Social Research (1-6)
418. The Development of Social Thought (3)
423. Population Research (3)
424. Social Change (3)
426. Introduction to Public Welfare (3)
427. Social Case Work (3)
429. Social Stratification (3)
450. Community Organization (3)
454. Industry and the Community (3)

455. Occupations and Professions (3)
470. Use of Statistics in Sociology (3)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

501. Analytical Social Theory (3) The nature, general types, and origins of sociological theory; problems in the logic of sociological inquiry.

502. Contemporary Sociological Theory (3) Survey of leading sociological works written during the last five decades.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

505. Current Social Theory (3) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-6)

510. Field Work in Sociology (1-6)

513. Seminar in Sociological Research Problems: A. Research Techniques; B. Current Research (3-6) Prerequisite: 3 credits in statistics.

515. Seminar in Community Studies (3)

523. Population Problems (1-6)

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572. Methods of Sampling (3) Application of sampling techniques to sociological research.

SOLID STATE TECHNOLOGY

Rustum Roy
Chairman of the Committee on Solid State Technology
121 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

The aim of this program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The subject matter, taught by various departments, is grouped into four areas: (1) the structure of solids, (2) theory related to the solid state, (3) properties of solids, and (4) reactions of solids.

Course work should be so distributed that one area is encompassed in depth while a substantial number of credits is chosen from any combination of the other areas. Thesis research on various aspects of the solid state may be conducted in appropriate departments in the Colleges of Engineering, Mineral Industries, and Science.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. They should be specifically interested in an interdisciplinary program of study and research.

SPEECH

Robert T. Oliver, *Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Arnold, Oliver, Schug, and Zelko; Associate Professors Brubaker, Fife, Holtzman, Nelson, and White; Assistant Professors Dunham and Olbricht.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted, but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and Spch. 502 are required of all graduate students who do not have their equivalents.

A thesis is required of all M.A. candidates in this major.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Schug*
402. General Semantics (3) *Mr. Brilhart*
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Composition (3) *Mr. Arnold*
415. Experimental and Applied Phonetics (3) *Mr. Brubaker*
425. (Brcst. 425) Radio Programming and Performance (3) *Mr. Nelson*
431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Mr. Brubaker*
435. (Brcst. 435) Radio and Television Programming (3) *Mr. Nelson*
437. (Brcst. 437) Television Programming and Performance (3) *Mr. Hungerford*
445. Contemporary Public Address (3) *Mr. Oliver*
450. Discussion: Research and Theory (3) *Mr. Zelko*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*

500. Seminar in American Oratory (2-4) History of American oratory, with application of critical standards to the work of specific orators. Prerequisite: 6 credits in speech, including Spch. 200. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Dunham*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

510. Seminar in Speech Pedagogy (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Oliver*

520. Seminar in Speech Science (2-4) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Mr. Brubaker*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Holtzman*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communication skills. *Mr. Zelko*

555. Speech Communication: Problems and Principles (2-4) Prevalent theories of speech influence. *Mr. Oliver*

560. Public Address (2-4) Discussion and criticism of speech outline, manuscript, content, composition, and delivery. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Schug*

575. Research Problems in Speech (1-12) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology.

SPEECH PATHOLOGY AND AUDIOLOGY

Eugene T. McDonald
In Charge of Graduate Programs in Speech Pathology and Audiology
2S Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors McDonald and Siegenthaler; Associate Professors Berlin and Frick; Assistant Professor Raabe.

Students may specialize in either speech correction or audiology. Admission to study for the master's degree requires 27 credits in clinical speech and hearing, education, and psychology, including at least 9 in speech correction and/or audiology.

Applicants for the M.S. degree must have had a course in statistics; applicants for the M.Ed. degree must have had student teaching. Applicants for the M.S. degree may count credits in speech science toward the required 27 credits.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing,

counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

STATISTICS

James B. Bartoo, *Chairman of the Committee on Statistics*
231 McAllister Building

No advanced degree is offered in this field, but a candidate with a major in another field may choose a minor in statistics upon approval by his major department.

This minor is intended to facilitate development of a coherent program of study in this vital branch of the scientific method. The candidate will be expected to become conversant with the broad field of statistics and to become reasonably proficient in the statistical methods particularly useful in the subject-matter areas of his major field. The member of the candidate's committee representing the minor in statistics will have responsibility for determining course work acceptable in satisfying requirements for the minor.

The minimum requirements for a minor for a master's degree are 3 credits in mathematical statistics and 6 in applied statistics. For a doctor's degree a minimum of 15 credits in statistics is required for a minor, of which at least 6 must be mathematical statistics and at least 6 must be applied statistics.

Courses in mathematical statistics are: Math. 409, 410, 542, and 543.

Courses in applied statistics are: Ag. 400; Ag.Ec. 505, 520; Ag.Ed. 521v; Agro. 512, 545; B.S. 500, 501; Econ. 510; Ed.Psy. 490, 590; For. 450; I.E. 423; Meteo. 450; Min. 513, 514, 526; Psy. 415, 515, 527; and Soc. 470, 572.

THEATRE ARTS

Walter H. Walters, *Head of the Department*
201 Schwab Auditorium

Degree Conferred: M.A.
Graduate Faculty: Professors Neusbaum, Smith, and Walters; Associate Professors Reifsneider and Yeaton.

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

A course in basic acting, one in directing, and one in theatre crafts, or their equivalents, are required for admission. In addition, the student must have had 12 credits divided between speech and the arts (including music, sculpture, painting, architecture, and other courses in which art is practiced); or a minimum of 9 credits in one of these; or a minimum of 9 credits in English and literature, including at least 6 in dramatic literature, or 3 in dramatic literature and 3 in advanced creative writing.

A thesis is required of all M.A. candidates in this major.

THEATRE ARTS (THEA)

404. Styles of Acting (3-6)
412. Advanced Scene Design (3)
413. Stage Lighting (3)
414. Stage Costuming (3)
415. Theatre Organization and Management (3)
421. Advanced Playwriting (3)
431. History of the Theatre (3)
433. Dance for the Theatre (3)
442. Creative Dramatics with Children (3)
443. Marionettes and Puppetry (3)
451. Directing (3)
452. Central Staging (3)
470. Theatre Production (1-6)
481. (Brcst. 481) Television Drama (3)
482. (Brcst. 482) Radio and Television Directing (3)

501. Problems of Directing (3-6) Seminar in problems of production with particular stress on direction. Students will direct plays under staff supervision.

502. Seminar in the Technical Problems of Dramatic Production (3-6) Prerequisite: Thea. 11.

504. Seminar in Styles of Acting (3-6) Practical work required of each student.

506. Evaluation and Appreciation of Modern Dramatic Entertainment (3) Prerequisites: Thea. 1, 61.

507. Seminar in Fundamental Theories of Theatre and Drama (3-6)

521. Playwriting (3-6) Prerequisites: Thea. 21, 421.

VOCATIONAL INDUSTRIAL EDUCATION

George L. Brandon
Head of the Department of Vocational Education
245 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Brandon and Williams.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved curriculum in vocational industrial education is required for admission.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)
403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (4)
415v. Problems in Coordinating Vocational Education (3)

420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. Vocational Education for Administrators (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. Research in Vocational Education (3) Research techniques in vocational industrial education.

558v. Emerging Problems in Industrial and Technical Education (2-3 per unit)
Unit A. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.
Unit B. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.
Unit C. State and Local Supervision and Administration (2-3) The more important recent problems in organization, supervision, and administration.
Unit D. Vocational Technical Education (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT

Bertil G. Anderson
Head of the Department of Zoology
212 Frear Laboratory

or

Robert E. McDermott
Head of the Department of Forest Management
109 Forestry Building

Degree Conferred: M.S.

Graduate programs in the field of wildlife management are offered by the Department of Zoology for students primarily interested in the animal aspects, and by the Department of Forest Management for those primarily interested in the habitat aspects.

ZOOLOGY

Bertil G. Anderson, *Head of the Department*
212 Frear Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Anderson, Anthony, Cooper, and Davis; Associate Professors Bellis, Boyle, and Wood; Assistant Professors Houlihan and Smyth.

Students may specialize in animal behavior, bioacoustics, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, physiology, population dynamics, or wildlife management.

In order to undertake graduate work in zoology, students are required to have had 24 credits in zoology and related biological sciences; and they should have had chemistry through organic chemistry. Courses in physics and mathematics are also advantageous. A limited deficiency can be made up without degree credit while pursuing graduate work.

ZOOLOGY (ZOOL)

401.	(Pty.Sc. 401, Psy. 401) Animal Behavior (3)	*Mr. Hale*
403.	(Ent. 403) Systematics (3)	*Mr. Boyle*
405.	(Bot. 405) General Cytology (3)	*Mr. Grun*
408.	Mammalogy (4)	*Mr. Davis*
410.	General Limnology (3)	*Mr. Cooper*
415.	The Literature of Zoology (1)	*Mr. Anderson*
416.	The Methods of Research in Zoology (2)	*Mr. Anderson*
417.	Invertebrate Zoology (3)	
419.	General Animal Ecology (3)	*Mr. Bellis*
421.	Comparative Anatomy of Vertebrates (4)	*Miss Lehmann*
422.	(Bot. 422) Advanced Genetics (3)	*Mr. Wright*
437.	Histology (4)	*Mr. Anthony*
440.	Embryology (4)	*Miss Lehmann*
444.	Zoological Problems (1-6)	
448.	Ornithology (3)	*Mr. Wood*
450.	Ichthyology (3)	*Mr. Cooper*
461.	Animal Parasitology (3)	
471.	Vertebrate Physiology (3)	

505. (Bot. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Zool. (Bot.) 405 or 422. Spring term, odd years. *Mr. Grun*

508. Advanced Parasitology (3) Advanced work on the structure, life cycle, and control of parasites.

509. Techniques in Wildlife Management (2) Evaluation of procedures designed to manage populations of game and fish; elements of statistics of birth and mortality rates; census methods. Fall term. *Mr. Davis*

512. Seminar (1) Review of current zoological literature. Required of graduate students majoring in zoology and entomology.

520. Special Topics (1-6)

524. (Bot. 524) Seminar in Genetics (1 per term) *Mr. Wright*

525. History of Biology (3) Historical development of biological knowledge and theories. Fall term.

528. (Bot. 528) Population Genetics (3) Factors affecting gene frequency, genotype frequency, genotype-environmental interaction, and genetic relationship in natural and artificial populations. Winter term, even years.

533. (Bot. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

537. (Bot. 537, Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term.

541. Cellular and Comparative Physiology (3) Basic functions of animal cells and their variations in the animal kingdom. *Mr. Smyth*

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term. *Mr. Davis*

551. Fisheries Management (3) Basic principles underlying management of inland waters for fish production. Summer term, even years. *Mr. Cooper*

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals.

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale, Schein, and Davis*

583. General Endocrinology (2) Anatomy and physiology of the organs of internal secretion; role of hormones in metabolism and development. Spring term, odd years. *Mr. Anthony*

587. Biology of Sex (2) Hereditary and embryological aspects, problems in gonadal differentiation, cyclic reproductive phenomena, actions of the hormones. Spring term, even years. *Mr. Anthony*

Other Elective Graduate Courses

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

ASTRONOMY (ASTRO)

430. General Astronomy for Teachers (3)
470. Solar Physics (3)
490-491. Introduction to Astrophysics (3 each)

BROADCASTING (BRCST)

425. (Spch. 425) Radio Programming and Performance (3) *Mr. Nelson*
435. (Spch. 435) Radio and Television Programming (3) *Mr. Nelson*
437. (Spch. 437) Television Programming and Performance (3) *Mr. Nelson*
481. (Thea. 481) Television Drama (3)
482. (Thea. 482) Radio and Television Directing (3)
492. (Journ. 492) Public Affairs Broadcasting (3) *Mr. Froke*

COMPUTER SCIENCE (CMP SC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
490. Special Topics in Computer Science (1-9)

ENGINEERING (ENGR)

431. Digital Computer Programming (3)
450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

531. Advanced Digital Computer Programming (3) Nonnumerical applications; symbol manipulation, syntactical analysis, and translation of artificial languages; heuristic methods, learning mechanisms, artificial intelligence. Prerequisite: Engr. 431.

GREEK (GREEK)

421. Greek Tragedy (3)
422. Greek Comedy (3)

500. Greek Composition (2) Translation of extended narrative passages into Attic Greek; thorough review of forms and syntax; attention to rhetorical elements of the language.

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

LABOR-MANAGEMENT RELATIONS (L M R)

411. Trade Union Administration (3)
421. Labor Education (3)

LANDSCAPE ARCHITECTURE (L ARCH)

425-426. Landscape Construction Problems (3 each)	*Mr. Wilson*
427. Landscape Construction Problems (2)	*Mr. Wilson*
434. (Rc.Ed. 434) Recreation Areas and Facilities (3)	*Mr. Miller*
454-455-456. Landscape Design (3 each)	*Mr. Miller*
460-461-462. Advanced Landscape Design (4 each)	*Mr. Polakowski*
471. Park Design and Administration (2-4)	*Mr. Wilson*
472. Site Planning of Institutional and Public Projects (2)	*Mr. Miller*
473. Site Planning of Institutional and Public Projects (2)	*Mr. Miller*

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects. Prerequisite: L.Arch. 456.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LATIN (LATIN)

428. Lucretius (3)	*Mr. Krauss*
429. Quintilian (3)	*Mr. Krauss*
431. Juvenal (3)	*Mr. Krauss*

500. Latin Literature (3) Lectures and collateral readings on the major forms of Latin literature; readings in the original Latin to supplement the lectures. *Mr. Krauss*

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. *Mr. Krauss*

502. Latin Epigraphy (3) Lectures and readings on Roman inscriptions; illustrative exercises. *Mr. Krauss*

503. Latin Paleography (3) The Latin alphabet, writing materials, Roman book and cursive hands; illustrative exercises. *Mr. Krauss*

504. Roman Topography (3) Physical development of the city of Rome, its walls, aqueducts, bridges, streets, forums, public buildings, temples, etc.; building materials and methods of construction. *Mr. Krauss*

510. Latin Seminar (3) *Mr. Krauss*

518. Latin Research (1-3) Prosecution of an assigned problem under the guidance of a member of the department.

LIBERAL ARTS (L A)

500-501. Fundamentals of Linguistics (3 each) Interrelated problems of language discussed from four points of view: modern structural linguistics, historical linguistics, social psychology, and philosophy.

LIBRARY SCIENCE (L SC)

403. Intermediate Dictionary Cataloging and Subject Headings (3)
405. Intermediate Reference Work and Bibliography (3)

MINERAL SCIENCES (MN SC)

411. Instrument Techniques Applied to Mineral Science Problems (1-3)
421. X-ray Diffraction (3)

510. X-ray and Electron Diffraction Analysis as Applied to Minerals and Metals (2-4) Prerequisite: Mn.Sc. 421. *Mr. Vand*

513. Semiconductor Physics (3) Electronic structure of solids; electronic transport phenomena; semiconductor materials; luminescence. Prerequisite: Phys. 400 or E.E. 32.

520. Electron Microscopy in Mineral Science Research (1-4) Prerequisite: Mn.Sc. 411, Unit B.

540. Solid State Structures and Reactions in Mineral Systems (2-4) Crystal chemical approach to solid state reactions, sintering, melting, hardness, thermal expansion, and behavior of matter under high pressure. *Mr. Weyl*

RELIGIOUS STUDIES (RL ST)

*400. Religious Ideas of Great Men (1)
401. Religious Philosophy of the Great Reformers (3)
402. Contemporary Religious Thought (3)
410. Biblical Studies: Old Testament (3)
420. Biblical Studies: New Testament (3)
430. Religion and Morality (3)

VETERINARY SCIENCE (V SC)

400. Veterinary Anatomy and Physiology (3)
401. Infectious Diseases of Domestic Animals (3)

515. (Bact. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Bact. 410.

*May be repeated for a maximum of 3 credits.

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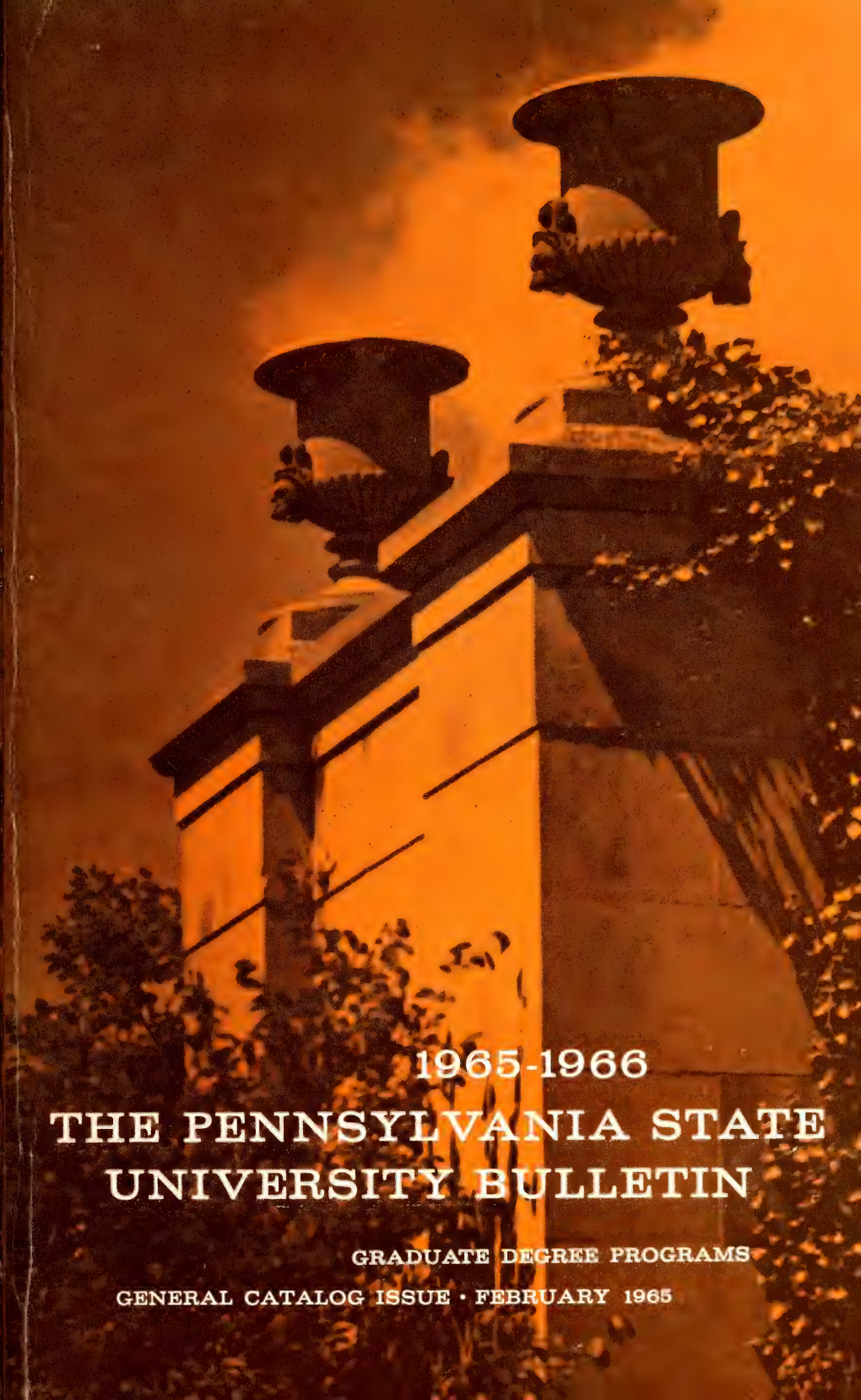
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1965-1966

THE PENNSYLVANIA STATE UNIVERSITY BULLETIN

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE · FEBRUARY 1965

OFFICES OF THE GRADUATE SCHOOL

University Park Campus
101 Willard Building
University Park, Pa., 16802
Telephone: Area Code 814, 865-6323

King of Prussia Graduate Center
Route 23 and Henderson Road
King of Prussia, Pa., 19406
Telephone: Area Code 215, 265-5400

Susquehanna Valley Graduate Center
2980 North Second Street
Harrisburg, Pa., 17110
Telephone: Area Code 717, 233-1678

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UNIVERSITY PARK, PA., 16802

1965-1966

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE • FEBRUARY 1965

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*GRADUATE CALENDAR

WINTER TERM 1965

NOVEMBER 1964

5 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1965

5 Thursday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1965

JANUARY 1965

5-6 Tuesday and Wednesday—Winter Term Registration

5-6 Tuesday and Wednesday—Oral Examination in Foreign Languages for Advanced Degree Candidates

7 Thursday—Winter Term Classes Begin 8 a.m.

7 Thursday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

16 Saturday—Last Date for Adding Courses to Approved Schedules

19 Tuesday—Graduate Faculty Meeting

25 Monday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in March

FEBRUARY

1 Monday—Written Foreign Language Examinations for Advanced Degree Candidates

16 Tuesday—Graduate Faculty Meeting

20 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

27 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates

27 Saturday—Last Date for a March Graduate to Deliver Master's Thesis to Adviser

27 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally

MARCH

6 Saturday—Theses Due in Graduate School Office 12 Noon

6 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in March

17 Wednesday—Winter Term Classes End 9:55 p.m.

18-20 Thursday to Saturday—Final Examinations

21 Sunday Afternoon—Commencement

SPRING TERM 1965

JANUARY 1965

26 Tuesday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1965

26 Tuesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1965

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*This calendar was approved July 13, 1964. It is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

MARCH

26-27 Friday and Saturday—Spring Term Registration
26-27 Friday and Saturday—Oral Examination in Foreign Languages for Advanced Degree Candidates
29 Monday—Spring Term Classes Begin 8 a.m.
29 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

APRIL

7 Wednesday—Last Date for Adding Courses to Approved Schedules
12 Monday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in June
19 Monday—Written Foreign Language Examinations for Advanced Degree Candidates
20 Tuesday—Graduate Faculty Meeting

MAY

15 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
18 Tuesday—Graduate Faculty Meeting
22 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
22 Saturday—Last Date for a June Graduate to Deliver Master's Thesis to Adviser
22 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally
29 Saturday—Theses Due in Graduate School Office 12 Noon
29 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in June

JUNE

5 Saturday—Spring Term Classes End 12:25 p.m.
7-9 Monday to Wednesday—Final Examinations
12 Saturday—Commencement

SUMMER TERM 1965

APRIL 1965

19 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Summer Term 1965
19 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1965

JUNE

18-19 Friday to Saturday Noon—Summer Term Registration
18-19 Friday to Saturday Noon—Oral Examination in Foreign Languages for Advanced Degree Candidates
21 Monday—Summer Term Classes Begin 8 a.m.
21 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
30 Wednesday—Last Date for Adding Courses to Approved Schedules

JULY

*5 Monday—Independence Day Holiday
7 Wednesday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in September

*See footnote on page 5.

12 Monday—Written Foreign Language Examinations for Advanced Degree Candidates
20 Tuesday—Graduate Faculty Meeting

AUGUST

7 Saturday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee
14 Saturday—Last Date for Final Oral Doctoral Examination for September Graduatees
14 Saturday—Last Date for a September Graduate to Deliver Master's Thesis to Adviser
14 Saturday—Last Date for a September Graduate to Rent Cap, Gown, and Hood Locally
17 Tuesday—Graduate Faculty Meeting
21 Saturday—Theses Due in Graduate School Office 12 Noon
21 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in September
*30 Monday—Summer Term Classes End 9:55 p.m.
31 Tuesday—Final Examinations

SEPTEMBER

1-2 Wednesday and Thursday—Final Examinations
4 Saturday—Commencement

FALL TERM 1965

JULY 1965

23 Friday—Last Date for a Prospective Graduate Student to Apply for Admission to the Fall Term 1965
23 Friday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1965

SEPTEMBER

23-25 Thursday to Saturday Noon—Fall Term Registration
23-25 Thursday to Saturday Noon—Oral Examination in Foreign Languages for Advanced Degree Candidates
27 Monday—Fall Term Classes Begin 8 a.m.
27 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

OCTOBER

6 Wednesday—Last Date for Adding Courses to Approved Schedules
13 Wednesday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in December
18 Monday—Written Foreign Language Examinations for Advanced Degree Candidates
19 Tuesday—Graduate Faculty Meeting

NOVEMBER

13 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee
16 Tuesday—Graduate Faculty Meeting
20 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates

---

*Classes which would have met on Monday, July 5, will meet according to schedule on Monday, August 30, 1965.

20 Saturday—Last Date for a December Graduate to Deliver Master's Thesis to Adviser
20 Saturday—Last Date for a December Graduate to Rent Cap, Gown, and Hood Locally
†25 Thursday—Thanksgiving Day
27 Saturday—Theses Due in Graduate School Office 12 Noon
27 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in December

DECEMBER

†6 Monday—Fall Term Classes End 9:55 p.m.
7-9 Tuesday to Thursday—Final Examinations
11 Saturday—Commencement

WINTER TERM 1966

NOVEMBER 1965

6 Saturday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1966
6 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1966

JANUARY 1966

6-8 Thursday to Saturday Noon—Winter Term Registration
6-8 Thursday to Saturday Noon—Oral Examination in Foreign Languages for Advanced Degree Candidates
10 Monday—Winter Term Classes Begin 8 a.m.
10 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
18 Tuesday—Graduate Faculty Meeting
19 Wednesday—Last Date for Adding Courses to Approved Schedules
26 Wednesday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in March
31 Monday—Written Foreign Language Examinations for Advanced Degree Candidates

FEBRUARY

15 Tuesday—Graduate Faculty Meeting
26 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

MARCH

5 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
5 Saturday—Last Date for a March Graduate to Deliver Master's Thesis to Adviser
5 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally
12 Saturday—Theses Due in Graduate School Office 12 Noon
12 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in March
19 Saturday—Winter Term Classes End 9:55 p.m.
21-23 Monday to Wednesday—Final Examinations
26 Saturday—Commencement

†Classes which would have met on Thursday, November 25, will meet according to schedule on Monday, December 6, 1965.

SPRING TERM 1966

JANUARY 1966

31 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1966

31 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1966

MARCH

31 Thursday Afternoon—Spring Term Registration

31 Thursday—Oral Examination in Foreign Languages for Advanced Degree Candidates

APRIL

1-2 Friday to Saturday Noon—Spring Term Registration

1-2 Friday to Saturday Noon—Oral Examination in Foreign Languages for Advanced Degree Candidates

4 Monday—Spring Term Classes Begin 8 a.m.

4 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

13 Wednesday—Last Date for Adding Courses to Approved Schedules

19 Tuesday—Graduate Faculty Meeting

20 Wednesday—Last Date for Paying Thesis Fees and for Informing Recorder of Intention to Graduate in June

25 Monday—Written Foreign Language Examinations for Advanced Degree Candidates

MAY

17 Tuesday—Graduate Faculty Meeting

21 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee

28 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates

28 Saturday—Last Date for a June Graduate to Deliver Master's Thesis to Adviser

28 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally

JUNE

4 Saturday—Theses Due in Graduate School Office 12 Noon

4 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in June

11 Saturday—Spring Term Classes End 9:55 p.m.

13-15 Monday to Wednesday—Final Examinations

18 Saturday—Commencement

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Glenn Z. Stevens, Ph.D. (Minnesota)	*Professor of Agricultural Education*
Harlan Stevens, Ph.D. (Duke)	*Assistant Professor of Mathematics*
Robert W. Stone, Ph.D. (Iowa State)	*Professor of Bacteriology*
Randall S. Stout, Ph.D. (Pittsburgh)	*Professor of Economics*
Werner F. Striedieck, Ph.D. (Michigan)	*Associate Professor of German*
Earl P. Strong, Ed.D. (N.Y.U.)	*Professor of Management*
Greenville K. Strother, Ph.D. (Penn State)	*Assoc. Professor of Biophysics*
Vladimir Stubican, Dr.Phil., D.Sc. (U. Zagreb)	*Assoc. Prof. of Ceramic Technology*
George A. Stull, D.Ed. (Penn State)	*Assistant Professor of Physical Education*
H. Tracy Sturcken, Ph.D. (North Carolina)	*Professor of Romance Languages*
Joseph T. Sullivan, Ph.D. (Purdue)	*Professor of Phytochemistry*
Shiou-Chuan Sun, Sc.D. (M.I.T.)	*Professor of Mineral Preparation*
M. Richard Sussman, Ph.D. (Michigan)	*Associate Professor of Finance*
A. Bruce Sutherland, Ph.D. (Pennsylvania)	*Professor of English Literature*
Robert W. Taft, Jr., Ph.D. (Ohio State)	*Professor of Chemistry*
James Tammen, Ph.D. (California)	*Associate Professor of Plant Pathology*
Willa C. Taylor, M.A. (N.Y.U.)	*Professor of Music*
William D. Taylor, Ph.D. (Manchester)	*Assistant Professor of Biophysics*
A. Frank Tesi, Ph.D. (Pittsburgh)	*Assoc. Professor of Clothing and Textiles*
Edward C. Thaden, D.U.P. (Paris)	*Associate Professor of European History*
Pericles S. Theocaris, D.Phys.Sci. (Paris)	*Visiting Prof. of Engineering Mechanics*
George A. Theodorson, Ph.D. (Cornell)	*Associate Professor of Sociology*
Deno G. Thevaos, Ed.D. (Columbia)	*Assoc. Prof. of Education and Psychology*

Glenn N. Thiel, M.Ed. (Penn State)	*Professor of Physical Education*
Walter I. Thomas, Ph.D. (Iowa State)	*Professor of Agronomy*
S. Earl Thompson, D.Ed. (Illinois)	*Prof. of Hotel and Institution Administration*
Charles P. Thornton, Ph.D. (Yale)	*Associate Professor of Petrology*
George L. Thuering, M.S. (Penn State), M.E., P.E.	*Prof. of Industrial Engineering*
Clarence E. Thurber, Ph.D. (Stanford)	*Assoc. Prof. of Pol. Sci. and Pub. Adm.*
Thomas T. Thwaites, Ph.D. (Rochester)	*Assistant Professor of Physics*
Gerald M. Torkelson, D.Ed. (Penn State)	*Professor of Education*
Alan Trachtenberg, Ph.D. (Minnesota)	*Assistant Professor of English*
Howard O. Triebold, Ph.D. (Minnesota)	*Professor of Biochemistry*
Alfred A. Triolo, Ph.D. (Illinois)	*Assistant Professor of Romance Languages*
Clarence E. Trotter, Ph.D. (Minnesota)	*Professor of Marketing*
George Tsoumis, D.For. (Yale)	*Assistant Professor of Wood Technology*
Albert G. Tsugawa, Ph.D. (Michigan)	*Associate Professor of Philosophy*
Loren D. Tukey, Ph.D. (Ohio State)	*Associate Professor of Pomology*
O. Frank Tuttle, Ph.D. (M.I.T.)	*Professor of Geochemistry*
Warren N. Underwood, C.E. (Princeton), P.E.	*Assoc. Professor of Civil Engineering*
Hugh B. Urban, Ph.D. (Penn State)	*Associate Professor of Psychology*
Vladimir Vand, D.Sc. (Glasgow)	*Professor of Crystallography*
Abram W. VanderMeer, Ph.D. (Chicago)	*Professor of Education*
Edward B. VanOrmer, Ph.D. (Columbia)	*Professor of Education and Psychology*
Francis J. Vastola, Ph.D. (Penn State)	*Assoc. Professor of Fuel Technology*
Kuppuswami Vedam, Ph.D. (Indian Inst. of Sci.)	*Assoc. Prof. of Solid State Science*
Dorothy H. Veon, Ed.D. (Columbia)	*Professor of Education*
Robert K. Vierck, M.S. (Iowa), P.E.	*Professor of Engineering Mechanics*
Carl Volz, Ph.D. (Penn State)	*Professor of Electrical Engineering*
Herbert A. Wahl, Ph.D. (Penn State)	*Professor of Botany*
Darrell E. Walker, Ph.D. (California)	*Professor of Plant Breeding*
Philip L. Walker, Jr., Ph.D. (Penn State)	*Professor of Fuel Technology*
Walter H. Walters, Ph.D. (Western Reserve)	*Professor of Theatre Arts*
Wilber W. Ward, D.For. (Yale)	*Associate Professor of Forestry*
John M. Warren, Ph.D. (Wisconsin)	*Professor of Psychology*
Thomas Wartik, Ph.D. (Chicago)	*Professor of Chemistry*
John B. Washko, Ph.D. (Wisconsin)	*Professor of Agronomy*
R. Hadly Waters, Ph.D. (Pennsylvania)	*Professor of Transportation*
George H. Watrous, Jr., Ph.D. (Penn State)	*Professor of Dairy Manufacturing*
Robert J. Watson, Ph.D. (Penn State)	*Assistant Professor of Geophysics*
Arthur H. Waynick, Sc.D. (Harvard)	*Professor of Electrical Engineering*
Wayne Webb, Ph.D. (Iowa)	*Professor of Physics*
Jon N. Weber, Ph.D. (Toronto)	*Assistant Professor of Geochemistry*
Robert L. Weber, Ph.D. (Penn State)	*Associate Professor of Physics*
Stanley Weintraub, Ph.D. (Penn State)	*Associate Professor of English*
Winston R. Weisman, Ph.D. (Ohio State)	*Professor of Art History*
Yechiel Weitsman, Ph.D. (Rensselaer)	*Asst. Professor of Engineering Mechanics*
Arthur M. Wellington, M.A. (Ohio State)	*Professor of Counselor Education*
George E. Wellwarth, Ph.D. (Chicago)	*Assistant Professor of English*
Clifford C. Wernham, Ph.D. (Cornell)	*Professor of Plant Pathology*
Frederick L. Wernstedt, Ph.D. (U.C.L.A.)	*Associate Professor of Geography*
Paul N. West, M.A. (Columbia)	*Associate Professor of English*
David L. Westby, Ph.D. (Michigan State)	*Assistant Professor of Sociology*
Woldemar Weyl, Dr.Ing. (Aachen)	*Evan Pugh Res. Prof. of Phys. Sci.*
Francis L. Whaley, Ph.D. (Michigan)	*Associate Professor of Psychology*
Ralph H. Wherry, M.A. (Penn State), C.L.U.	*Wm. Elliott Prof. Life Insurance*
Benjamin A. Whisler, Sc.D. (Harvard), P.E.	*Professor of Civil Engineering*
Eugene E. White, Ph.D. (Louisiana State)	*Associate Professor of Speech*
William B. White, Ph.D. (Penn State)	*Assistant Professor of Geochemistry*

Duane H. Whittier, Ph.D. (Illinois)	*Assistant Professor of Philosophy*
Edward W. Wickersham, Ph.D. (Wisconsin)	*Assistant Professor of Zoology*
Thomas A. Wiggins, Ph.D. (Penn State)	*Professor of Physics*
Arthur L. Williams, Ph.D. (Pennsylvania), C.L.U.	*Assoc. Prof. of Insurance*
Eugene G. Williams, Ph.D. (Penn State)	*Associate Professor of Geology*
William A. Williams, Ed.D. (Pittsburgh)	*Professor of Industrial Education*
Merritt A. Williamson, Ph.D. (Yale), P.E.	*Professor of Engineering*
William O. Williamson, Ph.D., D.Sc. (London)	*Professor of Cer. Tech.*
Donald J. Willower, Ed.D. (Buffalo)	*Associate Professor of Education*
George F. Wislicenus, Ph.D. (California Tech.), P.E.	*Prof. of Aero. Eng.*
Kenneth H. Wodtke, Ph.D. (Utah)	*Asst. Prof. of Psychology and Education*
Francis A. Wood, Ph.D. (Minnesota)	*Asst. Professor of Forest Pathology*
Merrill Wood, M.S. (Penn State)	*Assoc. Professor of Zoology*
Richard N. Work, Ph.D. (Cornell)	*Assoc. Professor of Physics*
Harold D. Wright, Ph.D. (Columbia)	*Assoc. Professor of Mineralogy*
James E. Wright, Jr., Ph.D. (Cornell)	*Professor of Genetics*
Lauren A. Wright, Ph.D. (California Tech.)	*Professor of Geology*
Peter J. Wyllie, Ph.D. (St. Andrews)	*Associate Professor of Petrology*
Jack Yahia, Ph.D. (Northwestern)	*Assistant Professor of Physics*
Kelly Yeaton, M.A. (Washington)	*Assoc. Professor of Theatre Arts*
Philip Young, Ph.D. (Iowa)	*Professor of American Literature*
Joseph Zafforoni, Ed.D. (Columbia)	*Associate Professor of Education*
Wilbur Zelinsky, Ph.D. (California)	*Professor of Geography*
Harold P. Zelko, M.A. (Ohio State), LL.B.	*Professor of Speech*
Leonard N. Zimmerman, Ph.D. (Cornell)	*Professor of Bacteriology*
Harry D. Zook, Ph.D. (Penn State)	*Professor of Chemistry*
George S. Zoretich, M.A. (Penn State)	*Professor of Art*

LECTURERS

Arnold Addison, M.A. (West Virginia)	*Assoc. Prof. of Industrial Eng.*
Carl F. Barnes, Jr., M.A. (Columbia)	*Assistant Professor of Art History*
Leland L. Beik, Ph.D. (Columbia)	*Associate Professor of Marketing*
Clarence O. Bergeson, Ed.D. (Columbia)	*Associate Professor of Education*
Ward D. Bouwsma, Ph.D. (Michigan)	*Assistant Professor of Mathematics*
William S. Decker, M.A. (Iowa)	*Assistant Professor of Marketing*
Aaron Druckman, B.A. (Penn State)	*Associate Professor of Philosophy*
M. Geraldine Gage, Ph.D. (Cornell)	*Assistant Professor of Family Economics*
Stella R. Goldberg, Ed.D. (Columbia)	*Asst. Prof. of Child Dev. and Fam. Rel.*
Keith A. Hall, Ed.D. (Indiana)	*Assistant Professor of Education*
George Heitmann, Ph.D. (Princeton)	*Assistant Professor of Economics*
Barton L. Jenks, Jr., M.S. (Princeton), P.E.	*Assoc. Prof. of Mechanical Eng.*
Donald W. Johnson, Ed.D. (Colorado)	*Assistant Professor of Education*
Orville R. Keister, Ph.D. (Illinois)	*Assistant Professor of Accounting*
Oscar A. Kimmel, M.S. (Penn State)	*Assistant Professor of Farm Mechanics*
Jaan Kiusalaas, Ph.D. (Northwestern)	*Asst. Prof. of Engineering Mechanics*
Edgar C. Leduc, Ph.D. (Indiana)	*Asst. Prof. of Pol. Sci. and Pub. Admin.*
J. Campbell Lester, M.S. (Penn State), P.E.	*Professor of Mechanical Eng.*
Ronald W. Linker, Ph.D. (Johns Hopkins)	*Assistant Professor of History*
Alan R. Mandel, M.S. (Juilliard Sch. Music)	*Instructor in Music*
Robert L. Masson, Ed.D. (Buffalo)	*Assistant Professor of Education*
William J. McHale, D.Ed. (Penn State)	*Assoc. Prof. of Fam. Housing and Home Art*
Robert A. Moore, Ph.D. (Indiana)	*Assistant Professor of Mathematics*
Nell A. Murphy, D.Ed. (Stanford)	*Associate Professor of Education*
Wilburn W. Newcomb, M.A. (Göttingen)	*Assistant Professor of German*
Ivan L. Preston, M.A. (Michigan State)	*Assistant Professor of Advertising*

Mitchell Salim, Ed.D. (Wyoming)	*Associate Professor of Education*
John E. Searles, Ed.D. (Stanford)	*Associate Professor of Education*
John M. Shemick, D.Ed. (Illinois)	*Assoc. Prof. of Industrial Arts Ed.*
Charles J. Smith, M.S. (Carnegie Tech.), P.E.	*Assoc. Prof. of Civil Engineering*
Judith Stoyle, Ph.D. (Penn State)	*Asst. Prof. of Business Statistics*
Walter F. Westerfeld, M.S. (Penn State)	*Associate Professor of Botany*
John R. Zimmerman, M.S. (Lehigh)	*Asst. Prof. of Mechanical Engineering*

GENERAL INFORMATION

GRADUATE WORK at The Pennsylvania State University was first offered in 1862 when two graduate students were in residence. It was given more formal recognition in 1864 by the establishment of a "course for Graduates" designed for students who, after receiving the degree of Bachelor of Scientific Agriculture, wished to do advanced work leading to the degree of Master of Scientific Agriculture. For some time there were few graduate students, and graduate instruction was relatively unorganized. Later a committee of the University Senate was given the responsibility of establishing standards and regulations governing graduate work and the granting of advanced degrees. The Graduate School was organized in 1922. Until this time only masters' degrees and certain technical degrees had been conferred. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. Still later other degrees were approved.

The faculty of the Graduate School consists of the President and certain other general administrative officers of the University, the Deans, the Librarian, the heads of departments, and those members of the instructional staff who have been authorized by the proper agencies of the Graduate School to offer graduate courses and supervise research leading to theses. It controls all academic matters pertaining to the Graduate School, subject to review by the University Senate. The Graduate Faculty has approximately 850 members.

During the academic year 1963-64, 2,700 to 3,000 graduate students were enrolled each term. In this interval 906 advanced degrees were conferred, of which 201 were doctorates.

GRADUATE CENTERS—University Graduate Centers away from the main Campus at University Park are being established, beginning with the King of Prussia Center which was opened in 1963. A similar center will be in operation in Harrisburg in early 1965. Others are in the planning stage. Each Center will operate under the immediate direction of a resident assistant dean of the Graduate School. The programs to be offered in a Center will depend upon its location and the degree of interest and the availability of students in the immediate area.

The addresses of the Centers are given on the inside front cover of this bulletin. Interested students are urged to write directly to the dean at the Center for information on programs and courses.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at Penn State by scheduling relevant courses and research at University Park. Similarly a graduate student with an appropriate major at Penn State may earn credits at Jefferson which, upon advance approval by his major department, will be accepted in partial fulfillment of degree requirements at Penn State.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in this publication, the *Manual for Graduate Students,* and the *Thesis Information Bulletin,* and for meeting the standards and requirements expressed by these regulations. The *Manual,* which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Dean's office soon after admission.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not simply an extension of undergraduate work. It operates at a definitely higher level, demands scholarship of a high order, and emphasizes reasearch and creativity. It involves a minimum of formal requirements and regulations, and a maximum of student initiative and responsibility.

A student does not become a graduate student merely by enrolling for advanced courses after having received a baccalaureate degree. Formal admission to the Graduate School is required.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number which can be accepted will vary with departments and from term to term. In some fields all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted. In others, applications can be accepted up to the deadline date and, in the case of outstanding applicants, beyond it. The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the resources of the University to provide graduate programs of outstanding quality.

Admission is granted by the Dean of the Graduate School after approval of the application by the department in which the student plans to do his major work. Blanks to be used in making formal application for admission can be obtained from the Graduate School office. In general, a student may begin his graduate work in fall, winter, spring, or summer. Prospective students may write directly to the head of any department concerning graduate work in that specific field.

Students from other countries are encouraged to write to the Director of International Student Affairs for information concerning finances, housing, and other non-academic matters.

CREDENTIALS—An applicant for admission should provide complete credentials, in duplicate, sent directly from other institutions to the Dean of the Graduate School at least two months prior to the opening of the term in which he plans to begin his graduate program. If the applicant has attended more than one institution, two official transcripts of the work covered at each institution are required. This applies to the complete academic record, both undergraduate and graduate.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements for an advanced degree.

UNQUALIFIED ADMISSION—For unqualified admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must have maintained during his junior and senior years a minimum grade point average equivalent to 2.5 on The Pennsylvania State University grading scale (approximately half B and half C). Finally, he must ordinarily have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of required work depending upon the field of advanced study which the student proposes to enter. The minimum grade point average of 2.5 during the last two undergraduate years is a general requirement of the Graduate School. Individual departments may require a higher average for admission in their fields.

The above requirements apply particularly to the student who has recently completed an undergraduate program and is about to begin graduate study. An applicant who has done a year or more of graduate work in a recognized graduate school will be evaluated largely on the basis of the graduate record but with some attention to undergraduate achievement. For a mature person, recognized attainment in a pro-

fessional field will be considered, and reduced weight will be given to old undergraduate records.

Admission is frequently granted to applicants whose credentials are not complete because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School and as a consequence will be required to cease attending any 500-level courses for which he may have registered. He may continue to attend courses below the 500 level provided he applies for and is accepted for registration as an adjunct student.

CONDITIONAL ADMISSION—When a department has space for additional students, an applicant whose grade point average is below 2.5 may be admitted conditionally for one term under the following circumstances: He must have had at least one year of significant experience after receiving the bachelor's degree and be recommended for admission by his major department. The applicant's credentials must be on file in the Graduate School office at least three months before the proposed date of registration. He must devote full time to his studies during the term for which he is conditionally admitted unless he is a student at the King of Prussia Graduate Center or in a comparable situation where a full-time program is not available. In the latter case he may continue on a part-time basis until the equivalent of a full term has been completed. At the end of the student's first term (or equivalent first term in the case of a part-time student) his conditional admission will terminate. If an average grade of 3.0 has been earned, he may continue as a student with unqualified admission. If an average of 3.0 has not been attained, the student may not register again as a graduate student.

ADVISERS—To assist the student in planning his program, the head of his major department will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to make an appointment for an initial language proficiency interview at the Language Testing Center for International Students, 218 Sparks Building. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. Remedial work will be prescribed as indicated by the tests.

GUESTS OF THE UNIVERSITY—The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctors' degrees who may be visiting the University for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses, and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade point average of 3). Any senior with a 3.5 grade point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400 and 500 series courses toward an advanced degree at Penn State. Upon admission to the Graduate School such credits as are relevant to the graduate field of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major and minor departments. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

STUDENT CONDUCT

The University expects that students will conduct themselves in accordance with the standards normally followed by educated men and women and in accordance with the laws of the Nation, State, and Borough. The right is reserved to sever at any time the University connection of any student whose influence is found to be injurious to the standard of morals and scholarship of the student body, or whose conduct is prejudicial to the good name of the University.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

CLASSIFICATION

At the time of admission to the University students are classified as regular graduate, general graduate, adjunct, or undergraduate students depending upon their objectives and qualifications.

A change in classification for a graduate student is arranged through the Graduate School office and, in the case of a change from general to regular status, the approval of the head of the major department in which the student proposes to work is required.

A person holding a baccalaureate degree and working only for permanent certification as a teacher or administrator in the public schools is advised to apply for admission as a general graduate student.

REGULAR GRADUATE STUDENTS—Persons who plan to become candidates for advanced degrees at The Pennsylvania State University and have been formally admitted for advanced study in a particular field are designated as regular graduate students. The program of study is developed under the guidance of an adviser appointed by the head of the student's major department.

It should be emphasized that a student is not a "regular graduate student" unless he has been officially admitted to that status. Regular attendance in the Graduate School, or personal plans for future degree candidacy, do not in themselves carry with them the status or privileges of a regular graduate student.

A regular graduate student who has passed a candidacy evaluation is classified as a doctoral candidate.

GENERAL GRADUATE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a general graduate student. This classification includes those who plan to transfer credits to another institution and those who plan a special program of study not leading to an advanced degree.

The adviser for a general graduate student is appointed by the department head most closely associated with the student's field of interest. The student's status and

standing will be reviewed by the Dean of the Graduate School at each registration. He may remain a general graduate student longer than one term only with the permission of the Dean, and for definite and good reasons.

When a general graduate student wishes to become a regular graduate student—i.e., to work for an advanced degree at this institution—he should make application to the Dean of the Graduate School for change of status. His academic record will then be evaluated to determine whether or not he is prepared to undertake graduate work for a degree in the major field of his choice. He should understand that he may thereafter apply toward degree requirements only those credits earned as a general graduate student which fit definitely and logically into an integrated degree program. There is no upper limit to the number of credits that may be so applied; neither is there a guarantee that any such credits may be applicable.

ADJUNCT STUDENTS—An adjunct student is not a graduate student, inasmuch as he has not been admitted to the Graduate School, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses, provided he has attained at least junior standing in college.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until he has met the minimum requirements for his degree, he must register for each term in which he proposes to do either course work or research, or other work on his thesis, either on or off campus. In the case of research the number of credits shall be determined by the amount of time required for the investigation, one credit representing one week of full-time graduate work.

CONTINUITY OF REGISTRATION—Any student who has interrupted the normal sequence of his graduate program is required to apply to the Dean of the Graduate School for permission to resume graduate study. It is recognized that certain students typically will not attend the summer terms whereas others will concentrate their work in these terms. Both groups, as well as certain variants, meet the spirit of the policy.

In order to register for a given term, a student who has been previously enrolled will need to apply unless he has been registered for work at University Park, for thesis research in absentia (610), or for other Penn State work off campus during certain specific terms as follows:

Summer Term—Application required unless the student was registered for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered for the preceding fall term.

Spring Term—Application required unless the student was registered for the preceding winter term.

PROCEDURE—For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs, which is submitted to the Dean of the Graduate School for his approval. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done off the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed by the same deadline as applies on the campus.

A student must register for courses audited as well as for those taken for credit.

EXCEPTIONS—When a candidate has met minimum requirements for a degree,

further registration shall be required only for course work, project work, and research work requiring the use of University facilities and supplies (including laboratory, library, and others). This means, for instance, that a student who has earned 90 credits in a doctoral program and has met all requirements for the degree except for the completion of his thesis and the passing of the final oral examination need not register for the additional research which may be required, whether it be done at University Park or elsewhere, provided he does not use University facilities or supplies. On the other hand, a student who uses University facilities or supplies for his research must be registered for credit at all times, regardless of the number of credits that may accrue before he completes his work.

A candidate need not register for the term at the end of which the degree is to be conferred solely for the purpose of graduating. He will, of course, be required to register if he has a significant amount of work to complete unless relieved of this obligation by the previous paragraph. He will not be required to register if he has only minor revisions of his thesis to complete and/or the final oral examination to pass.

TIME OF REGISTRATION—Registration days for all students are indicated in the University Calendar.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructors to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the amount of time which he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

LOADS, ACADEMIC AND EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule in planning his academic program.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their Graduate School experience to a maximum extent. Therefore the Graduate School reserves the right to deny admission or registration to part-time students who (a) propose schedules of few credits which seem to reflect little real interest in graduate work or would not seem to require serious effort, or (b) wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality in their graduate work.

"Doing graduate work" means more than doing what is required in courses or in research. It means living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Overloads make it difficult and often impossible to do graduate work so conceived. Hence the following "protective" schedule of permitted loads for employed students has been adopted:

EMPLOYMENT	ACADEMIC LOAD
0 hours per week	8-10 credits allowed
10 hours per week	7- 9 credits allowed
20 hours per week	5- 7 credits allowed
30 hours per week	4- 5 credits allowed
40 hours per week	1- 4 credits allowed

This means, for example, that anyone working 20 hours per week (about half-time) whether as a half-time graduate assistant, as an employee on campus, or as an employee off-campus, will be limited in the amount of graduate work for which he may register to about three fifths of a normal full-time load (i.e., to 5-7 credits). The word employment is used in a very general sense and includes working for indirect compensation, such as housekeeping, working in the family business, maintaining a large vegetable garden, etc. Hence, all students who are thus employed will be expected to adjust their academic loads accordingly. Exceptions, in the case of students who have demonstrated unusual ability, must be arranged with the Dean of the Graduate School at the time of registration. (See also Visiting and Auditing Classes.)

A student holding a fellowship, graduate assistantship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no grade and cannot subsequently secure credit for work done in the course.

Ordinarily a student is not permitted to count courses for which he is registered as an auditor as a part of the minimum for which he is required to register by virtue of his status. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for the course as an auditor.

In the 1G and 2G courses offered by the language departments, visiting is not permitted and no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the language, he will be required to count the course as a part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

STATUS UNDER SELECTIVE SERVICE—As soon as an applicant has been admitted to the Graduate School, his local board will be informed *provided* the applicant requests it and has given the necessary information. As soon as he receives notification of admission, the applicant should check with the Associate Registrar to see that everything is in order.

A student is certified to be a full-time student insofar as Selective Service is concerned if he schedules at least 8 credits in a term, or if he holds an appointment as a quarter-time or half-time graduate assistant, or if he is serving an internship or holding a traineeship under approved conditions.

Whenever a student changes his status so as no longer to be considered a full-time student, fails to make satisfactory progress, or makes a drastic change in his declared goal, his local board will be notified.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality

grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade point equivalents are 4, 3, 2, 1, 0 respectively.

In courses below the 400 level a grade of F is failing. At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

In addition to the quality grades listed above, two symbols, "deferred" and R, may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "deferred" in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, the instructor may report the symbol R in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. An R remains on the student's transcript permanently. If, after having submitted a series of R symbols, the instructor reports a grade of A, B, C, D, or F for a specific term, this grade is considered to apply to the preceding series of registrations and to denote the quality of that entire series.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate, and to pay thesis fees at the beginning of the term in which he expects to receive an advanced degree. Deadlines are given in the calendar.

Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School for sufficient reasons. See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation.

All degrees conferred are tentative until final grade reports have been received even though the student's name may have appeared in the commencement program.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

Residents of Pennsylvania, $22 per credit with a maximum of $175 per term.

Nonresidents of Pennsylvania, on-campus work, $44 per credit with a maximum of $350 per term.

Nonresidents of Pennsylvania, research in absentia, $22 per credit with a maximum of $175 per term.

Total charge for a Vocational Education program, not exceeding 7 credits (vocational education courses are indicated by "v" following the course number), $22.

Tuition is the same for courses whether taken as an auditor or for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than 10 days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Dean of Admissions for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile of the one admitted (or of his parents, if

he is a minor) within the Commonwealth for a period of at least 12 months immediately preceding the date of such petition for reclassification; and, in addition, such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following the twelfth month after such change has taken place.

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor not later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIAL CHARGES (payable as occasion demands and applicable to all students):

Admission to the Graduate School	$10.00
Privilege of late registration	10.00
Privilege of late payment	25.00
Change of schedule, each change	2.00
Thesis binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Official transcript of record (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

A graduate student planning to operate a motor vehicle in the State College area should secure a copy of the leaflet *Parking and Traffic Regulations* from the Traffic Violations Officer, Room 203D, Hetzel Union Building.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fireproof, one-story, steel framework buildings. Forty-six one-bedroom units rent for $75 per month and 32 two-bedroom units rent for $85. The rent includes utilities except for electricity. Water is heated elec-

trically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle, opened in 1960, has 144 one-bedroom and 72 two-bedroom apartments in 16 two-story buildings of brick and frame construction. The units rent for $82.50 and $92.50 per month, including all utilities. The kitchens have double stainless steel sinks with disposal unit, a gas stove, kitchen cabinets, electric refrigerator, and a built-in chest of drawers in the bedroom; otherwise the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age or with children who will become school age during the term of the lease cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children. An application form for a Married Student Apartment may be obtained by writing to the Department of Housing and Food Services, Assignment Office, 23 Pollock Dining Hall, University Park, Pa., 16802. Telephone: Area Code 814, 865-7501.

A married student may also find accommodations in off-campus apartments, trailers, or rooms in private homes.

Some residence halls located on central campus provide for single students, both men and women. For detailed information write to Department of Housing and Food Services, Assignment Office, 23 Pollock Dining Hall, University Park, Pa., 16802. Telephone: Area Code 814, 865-7501. Other living accommodations are available, including rooms in private homes and lodging houses. The cost varies considerably depending upon the type of accommodation. The prospective student should make arrangements well in advance of the beginning of classes because it may be very difficult to find a convenient location at the last minute. Restaurants and the Hetzel Union Cafeteria on the campus are available for meals.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

ASSISTANTSHIPS

Approximately 1,200 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some departments. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department for information and application forms. Appointments are made upon the recommendation of the department head, subject to admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship requires a continuing demonstration of good scholarship.

The assistantships vary as follows:

QUARTER-TIME—The student may schedule 7-9 credits, receives a stipend in the range $270-$480 plus a grant-in-aid which covers tuition, will be required to give a maximum of 10 hours of service per week for 12 weeks, and will be con-

sidered to be following a full-time course of instruction under Selective Service regulations.

HALF-TIME—The student may schedule 5-7 credits, receives a stipend in the range $480-$1,020 plus a grant-in-aid which covers tuition, will be required to give a maximum of 20 hours of service per week for 12 weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

THREE-QUARTER-TIME—The student may schedule 4-5 credits, receives a stipend in the range $810-$1,350 plus a grant-in-aid which covers tuition, will be required to give a maximum of 30 hours of service per week for 12 weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by arrangement with the Dean of the Graduate School, provided the credit load and the service load are properly balanced in each term, and the total credit load over a series of terms is in conformity with the specified limits.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an earned extra grant-in-aid to cover tuition for the succeeding term without service, if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an earned extra grant-in-aid form from the head of the department in which he has held the assistantship and must follow the instructions on the form in making application.

A graduate assistant may not accept additional employment, either at the University or elsewhere, during the period for which service to the University is required under the appointment (12 weeks per term).

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS

More than 250 fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows carry a full-time graduate program, receive a stipend which varies with the award, and receive a grant-in-aid paid by the donor of the fellowship to provide for all tuition. They may not accept employment during the term of their appointment, nor are they required to render any service to the University. In some cases a fellow will be expected to limit his research to a broad field specified by the donor. Fellows are required to pay specific charges, such as admission, late registration, change of schedule, thesis binding, microfilming, and parking fees.

GRADUATE SCHOOL FELLOWSHIPS—Eleven fellowships, each paying a stipend of $2,000 for the fall, winter, and spring terms, and providing a grant-in-aid to cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding advanced graduate students in any field, although, ability of applicants being comparable, some preference is given to applicants majoring in the humanities and social sciences. An applicant must have completed at least one full year of graduate study prior to beginning the fellowship tenure and be a candidate for the doctoral degree.

Applications should be addressed to the Dean of the Graduate School and must be received by February 15 to be considered for the following fall, winter, and spring.

DEPARTMENTAL FELLOWSHIPS FROM FOUNDATIONS AND INDUSTRIES—At least 135 such fellowships, with various stipends, are awarded through the indi-

vidual departments. Information and application forms may be secured from the head of the major department concerned. The fellowships which are awarded will vary somewhat from year to year, but the following are typical of those which were available for 1963-64:

American Chemical Society Fellowship—Open to graduate students in chemistry and chemical engineering; stipend $1,800-$2,400.

American Chemical Society Fellowship—Open to graduate students in fuel technology; stipend $2,280.

American Chemical Society Fellowships (2)—Open to graduate students in geochemistry, mineralogy, and solid state technology; stipend $2,400.

American Chemical Society Fellowship—Open to graduate students in geology; stipend $2,400.

American Cyanamid Fellowship in Chemistry and Chemical Engineering—Open to graduate students for the final year of study leading to the Ph.D. degree. Awarded in alternate years to a chemist and to a chemical engineer; stipend $1,800.

American Iron and Steel Institute Fellowships (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400.

American Petroleum Institute Fellowships (5)—Open to graduate students in chemistry and physics for research concerning the synthesis and properties of high molecular weight hydrocarbons; stipend $1,710-$2,280.

American Petroleum Institute Fellowships (2)—Open to graduate students in geochemistry, ceramic technology, mineralogy, and solid state technology for research concerning the synthesis and properties of clays and related inorganic phases; stipend $2,640.

American Petroleum Institute Drilling Research Fellowship—Open to graduate students in mining or petroleum and natural gas engineering for studies related to drilling and rock penetration; stipend $2,400.

Armstrong Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry; stipend $640.

Atomic Energy Commission Graduate Traineeships in Nuclear Reactor Operations and Utilization (3)—Available to graduate students in nuclear engineering. Stipends comparable to the AEC Special Fellowships.

Carborundum Corporation Fellowship—Available to a graduate student in mineral preparation; stipend $2,400.

Continental Oil Company Fellowship—Available to graduate students in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

Continental Oil Company Fellowship in Petroleum Economics—For graduate work in mineral economics on petroleum economics; stipend $2,280.

Diamond Alkali Summer Fellowship—Open to graduate students in chemistry; stipend $650.

Esso Research and Engineering Postgraduate Fellowship in Chemistry and Chemical Engineering—Open to advanced graduate students for one year of study leading to the Ph.D. degree; stipend $1,800-$2,400.

W. S. Elliott Fellowship—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

General Electric Foundation Fellowship—Open to graduate students in ceramic technology; stipend $2,400-$2,600.

General Foods Fund Fellowships (2)—For graduate work with a major in home economics; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

Gulf Oil Company Fellowship in Petroleum and Natural Gas Engineering—For graduate work in petroleum production; stipend $2,400.

Hamilton Standard Fellowship—Open to graduates of this University in aerospace, electrical, and mechanical engineering, engineering mechanics, and physics; stipend $1,800.

H. R. Imbt Services, Inc. Fellowship—For graduate work in civil engineering in the field of civil engineering construction; stipend $2,400.

International Business Machines Corporation Fellowship—Open to an outstanding advanced graduate student in physical science, engineering, or in any field where his doctoral research is amenable to treatment by a digital computer; stipend $1,800-$2,500. Apply to the Dean of the Graduate School.

International Lead Zinc Research Organization Fellowships (2)—In support of research on the physics and chemistry of lead and zinc compounds. Open to students in solid state technology and allied fields; stipend $2,540.

Kopper's Summer Supplemental Teaching Fellowships (2)—Open to graduate students in chemistry; stipend $600.

Lead Industries Association Fellowship—Open to graduate students in ceramic technology for studies of lead oxide systems; stipend $2,208.

Marathon Oil Company Fellowship—Available to graduate students in petroleum and natural gas engineering; stipend $2,280.

Monsanto Summer Research Fellowships (2)—Open to graduate students in chemistry; stipend $650.

Edward Orton, Jr., Ceramic Foundation Fellowship—Open to students in ceramic technology for studies relating to kiln-fired ceramic bodies; stipend $2,400.

Owens-Corning Fiberglas Fellowship in Ceramic Technology—Open to graduate students in ceramic technology; stipend $3,000.

Owens-Illinois Fellowship—Open to graduate students in ceramic technology for studies in glass science and technology; stipend $3,000.

Pennsylvania Cooperative Fishery Unit Fellowship—Available to graduate students in zoology; stipend $2,400.

Pennsylvania Cooperative Wildlife Research Units Fellowships (4)—Available to graduate students in forestry, zoology, and related fields; stipend $2,400.

Pennsylvania Electric Association Fellowship—For graduate work in mineral economics on potential markets for fly ash; stipend $2,400.

Pennsylvania Natural Gas Men's Fellowship—For graduate work in petroleum and natural gas engineering for studies in gas technology; stipend $2,000.

Pennsylvania Power and Light Company Fellowship—Open to graduate students in mineral preparation; stipend $2,400.

Pittsburgh Plate Glass Fellowship—Open to graduate students in ceramic technology for fundamental studies of glass; stipend $3,000.

Radio Corporation of America Fellowship—Open to graduate students in electrical engineering; stipend $2,100-$3,000.

Shell Companies Foundation Fellowships (2)—Open to advanced graduate students in two of these fields in rotation: chemical engineering, chemistry, and petroleum engineering; stipend $2,000-$3,000.

Socony-Mobil Oil Fellowship—Available for graduate students in chemical engineering; stipend $1,500-$2,000.

Speer Carbon Fellowship—Open to graduate students in fuel technology for studies on carbon; stipend $2,400.

Stackpole Ferrite Fellowship—Open to students in ceramic technology and solid state technology; stipend $3,000.

Sprague Electric Company Fellowship—Open to students in ceramic technology and solid state technology; stipend $2,400.

Stauffer Chemical Company Fellowship in Chemistry—Open to a graduate student in chemistry for research on organometallic compounds; stipend $1,800.

Sun Oil Company Fellowship in Chemistry—Open to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

Union Carbide Summer Fellowships (4)—Open to graduate students in chemical engineering; stipend $300-$600.

U. S. Office of Education Fellowships in Speech Pathology and Audiology (5)—Open to graduate students majoring in this field; stipend beginning at $2,000 plus dependency allowance.

U. S. Office of Education Fellowships for Leadership Personnel in Education of

Exceptional Children (13)—Open to graduate students being prepared as leadership personnel in the education of the mentally retarded and the speech handicapped; stipend $2,000-$2,800 plus dependency allowance. Apply to the head of the Department of Special Education.

U. S. Public Health Service Traineeships in Clinical Psychology (12)—Open to selected graduate students in this area of psychology; stipend $1,800-$3,000.

U. S. Public Health Service Traineeships in Microbiology—Open to selected graduate students in microbiology; stipend $2,400-$2,700.

U. S. Public Health Service Traineeships in Public Health Nutrition—Open to selected graduate students in foods and nutrition; stipend $3,000.

U. S. Public Health Service Traineeships in Sanitary Engineering—Open to graduate students in sanitary engineering; stipend $3,600-$5,000.

U. S. Public Health Service Traineeships in Zoology (4)—Open to selected graduate students in zoology; stipend $2,400.

United States Steel Foundation Fellowship—Open to graduate students in the College of Mineral Industries for studies related to steel-making; stipend $2,880.

U. S. Vocational Rehabilitation Administration Traineeships in Speech Pathology and Audiology (11)—Open to graduate students majoring in speech pathology and audiology; stipend $2,400-$2,800.

U. S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in Counselor Education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (18)—Open to selected advanced graduate students in this area of psychology.

Wheelabrator Fellowship—Open to graduate students in industrial engineering, mechanical engineering, and metallurgy; stipend $1,500.

In addition, numerous grants are available from governmental agencies, industrial concerns, and foundations for the support of investigations of particular problems. Many of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS —Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration:

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelors' degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee. About 200 will be awarded.

National Aeronautics and Space Administration Predoctoral Traineeships in Space-Related Science—The National Aeronautics and Space Administration awards training grants to various recognized universities to increase the supply of scientists and engineers in space-related science and technology in order to meet the growing needs of the federal government's space research program. These grants permit a university to award a specified number of traineeships in science and engineering fields. The awards compare favorably with the best fellowships. In 1964-65 the University had 22 of these traineeships in physical science and engineering fields.

More may be available for 1965-66. No institution will know whether it has any available until late in the fall. Applicants should write to the graduate dean at the institution of their choice, or to the head of the department in their graduate field. More than 1,000 were awarded in 1964.

National Defense Graduate Fellowships—Under Title IV of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education makes an allotment of fellowships to certain approved new or expanded doctoral programs. The purpose of these three-year awards is to assist able beginning graduate students in obtaining their doctorates (with preference given to those interested in teaching in institutions of higher education) and to distribute graduate study facilities geographically. The University has had some of these fellowships in certain areas in past years. In 1964-65 there were 17 such recipients.

No institution knows until the fall of each year whether it will have any fellowships under this program for the following year. A federal announcement booklet is sent to all colleges each fall, listing the institutions which have fellowships in various fields. A senior should inquire from the dean of his college. Application is made directly to the graduate deans of the institutions having programs in the desired field. Most institutions have application deadlines from February 15 to 20. About 3,000 will be awarded for 1965-66.

National Science Foundation Cooperative Graduate Fellowships—The Graduate School participates in this program of fellowships available in the biological, engineering, mathematical, and physical sciences, anthropology, economics (excluding business administration), geography, history and philosophy of science, political science, psychology (excluding clinical), and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, and meteorology. Applications for the following year must reach the Dean of the Graduate School by about November 1. About 800 new awards will be made for 1965-66.

National Science Foundation Graduate Fellowships—These fellowships, which are somewhat different from the NSF Cooperative Fellowships mentioned above, are also awarded for graduate study in the biological, engineering, mathematical, and physical sciences, anthropology, economics (excluding business administration), geography, history and philosophy of science, political science, psychology (excluding clinical), and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, and meteorology. These fellowships are used at the university of one's choice. Application is made during the fall to the National Science Foundation, Washington, D. C., 20550. The application deadline is usually about December 11. About 900 new awards will be made for 1965-66.

National Science Foundation Graduate Traineeships in Engineering, Mathematical, and Physical Sciences—Although these traineeships were awarded only in engineering for 1964-65, they will also be available in mathematics and certain physical sciences at many institutions for 1965-66. The National Science Foundation awards training grants to various recognized universities to accelerate the output of graduate students in these fields and to help meet the Nation's future needs for scientific and professional manpower. These grants permit a university to award a specified number of traineeships, 80 per cent of which must go to first-year graduate students. These awards compare favorably with the best fellowships. In 1964-65 the University had 13 of these traineeships in engineering. More will probably be available in all three of these general areas for 1965-66. No institution will know until the middle of January whether it will have any available. Applicants should write to the graduate dean at the institution of their choice, or to the head of the department in their graduate field. About 2,000 new awards will be made for 1965-66.

National Science Foundation Science Faculty Fellowships—These awards are made to enhance the effectiveness of college faculty members who have at least three years' experience as full-time staff members, teaching science, mathematics, or engineering

mainly to undergraduates. They are awarded to those working for a Ph.D., or to those holding the degree and teaching in any of the fields supported by the NSF Graduate Fellowship Program. Tenure may be from 3 to 15 months and can be spread over three successive summers. About 350 will be awarded for 1965-66. Write the National Science Foundation, Washington, D.C., 20550. The application deadline for 1966-67 will be about the middle of October.

Study Fellowships for International Development—Through a grant from the Ford Foundation, the Inter-University Committee on Study Fellowships for International Development makes these awards for one year of study toward the master's degree to United States and Canadian citizens who have served in a volunteer capacity for more than one year in one of the developing countries and wish to devote a significant portion of their careers to development assistance. Fields of study include such areas as agriculture, business administration, community development, economics, engineering, English (to be taught as a second language), political science, public administration, and public health. The universities cooperating in this program are U.C.L.A., Chicago, Columbia, Cornell, Harvard, North Carolina, Penn State, Stanford, and Wisconsin. About 55 were awarded for 1964-65. Applications may be obtained from the central office for the program: Study Fellowships for International Development, 16 Carnegie Building, The Pennsylvania State University, University Park, Pa., 16802, or they may be obtained from overseas representatives of the Peace Corps. Completed applications for 1965-66 must be postmarked on or before January 31, 1965.

U. S. Public Health Service Predoctoral Fellowships—Available to graduate students in the basic sciences, such as biology, chemistry, zoology, physiology, biochemistry, biophysics, etc., as they relate to problems of health and disease; among the social sciences, in areas such as psychology and sociology, as they relate to health; and in some interdisciplinary fields, such as biostatistics, medical economics, cultural anthropology, etc. These fellowships are used at the university of one's choice and are more frequently awarded for second or third year graduate study. The Public Health Service also awards Air Pollution Special Fellowships to graduate students who are studying and doing research related to the prevention and abatement of air pollution; and similar Research Fellowships in Water Supply and Pollution Control are awarded to graduate students studying the causes, control, and prevention of water pollution. Application should be made to the Career Development Review Branch, Division of Research Grants, National Institutes of Health, Bethesda, Md., 20014, September 1, January 1, or April 1, to be considered at the November-December, March-April, and June-July review periods respectively. More than 1,500 were awarded for 1964-65.

Woodrow Wilson National Fellowships—Awarded by the Woodrow Wilson National Fellowship Foundation for first-year graduate study at the institution of one's choice, to outstanding students who show a clear preference for a career in college teaching, especially in the areas of the humanities and social sciences. Science and mathematics majors will be considered; but they must also apply for a National Science Foundation Fellowship, and if it is received, they must accept it in preference to the Woodrow Wilson award. Students must be nominated by a professor in their undergraduate college. The nomination is sent to the regional representative of the Woodrow Wilson Fellowships for the area in which that college is located. Interested students should consult the dean or other official of their college, or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J. Nominations must reach the regional chairman by October 31, each year. Approximately 1,000 fellowships are awarded.

OTHER AIDS

COUNSELORSHIPS FOR MEN—A number of appointments are available to men graduate students to serve as Resident Counselors in the undergraduate residence

halls for men. A counselor's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training and experience in personnel work are desirable, though not essential.

These appointments are for three terms (fall, winter, and spring). Remuneration is in the form of room, board, and exemption from the additional out-of-state tuition, if applicable. In addition, a grant-in-aid for full tuition is available to a limited number of the Resident Counselors selected. A counselor may not hold a fellowship or assistantship during the term of his appointment as a counselor. He may not engage in any other form of part-time employment. He may carry 7 to 9 credits per term.

Requests for information and application forms should be addressed to the Dean of Men, 117 Old Main.

SENATORIAL GRANTS—The University makes available annually a quota of 24 one-year (three-term) grants to each State Senator and to the Governor and the Lieutenant Governor. Each grant has a value of $35 per term or $105 for each three-term combination. Any undergraduate or graduate student who is a full-time student according to the regulations of his academic level is eligible to receive one of these grants. Nominations for these grants may be made by the above State officials at any time after March 1, for the three-term period which may begin in June or September as the student desires. The recipient is expected to maintain attendance and satisfactory scholarship or the grant will be canceled. The grant is applied to the reduction of the student's bill for the respective terms.

Any student interested in receiving this type of aid should contact the State Senator in his senatorial district or the Governor or the Lieutenant Governor.

SENIOR RESIDENT POSITIONS FOR WOMEN—Full-time salaried appointments as Senior Residents in undergraduate halls for women are available to qualified women graduate students. Responsibilities include working with student groups in a programming capacity, counseling, and supervising the residence hall during the evening. Some preference is given to persons working for a master's degree in higher education.

These positions permit the holders to take 4 graduate credits per term at $5.50 per credit. Appointments are made for the fall, winter, and spring terms. Special arrangements of hours of work and credits may be made for the summer term. It is thus possible to complete work for a master's degree in nine terms.

Requests for information and application forms should be addressed to the Dean of Women.

GRADUATE GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on the basis of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed 10 hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $175 per term, to non-Pennsylvanians, $350 per term. A few grants are available for students beginning graduate study in the winter or spring term, if applications are filed six weeks before registration for that term.

Applications should be addressed to the Dean of the Graduate School and must be received by March 15 to be considered for the following summer or fall.

DU PONT TEACHING AWARD IN CHEMISTRY—To be eligible for the E. I. du Pont de Nemours and Company Postgraduate Teaching Assistant Award, a graduate student must be currently serving as a part-time teaching assistant and preferably should have had two years of experience in this capacity. The recipient receives $1,200 in addition to the regular stipend paid him as a teaching assistant.

JOHN W. WHITE FELLOWSHIP—Awarded to two graduates of The Pennsyl-

vania State University each year on the basis of scholarship, need, character, and aptitude. The recipients may enroll in any approved college or university.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded annually through individual departments. A request for information should be directed to the department head in the field of the student's major interest.

A.A.U.W. SCHOLARSHIP—The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

LOANS ADMINISTERED BY THE UNIVERSITY—The Director of the Office of Student Aid has charge of all loans administered by the University, for both undergraduate and graduate students. Applications may be obtained from his office, 218 Willard Building. Funds are available from three sources:

University Loan Funds have been established through the generosity of University organizations, alumni, faculty, staff, and friends. Graduate students without assistantships who are registered for a full credit load may obtain long-term loans, while graduate assistants who are classified as full-time students by the Dean of the Graduate School may qualify for only short-term loans from these funds. Applicants must demonstrate a need for financial assistance in meeting University-related expenses and be United States citizens, except that international students may qualify for short-term loans if they can secure a responsible resident of Pennsylvania as cosigner of the note. The interest on long-term loans does not begin until after graduation and generally is at a low rate for the first two years.

National Defense Education Act Loan Funds are available for United States citizens from the Federal Government, this act having been expanded in the fall of 1964, to increase the amount allotted to each institution and to increase the ceiling on loans to graduate students to $2,500 per year. The forgiveness of half the loan over a five-year period for those entering teaching has been extended to college teaching and to teaching in private elementary and secondary schools, as well as to teaching in public elementary and secondary schools. Interest at 3 per cent does not start until one year after the borrower ceases to be a full-time student. Repayment in 10 annual installments then begins. Of course, repayment may be made sooner if desired.

The Alumni Graduate Student Loan Fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School Alumni who have received their bachelor's degrees elsewhere. The Graduate Student Association has also made sizable contributions to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and microfilming fee, job interview travel, etc. Students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

STATE HIGHER EDUCATION LOAN PLANS—A number of states have passed laws which enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in that state to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for legal residents of this State. A full-time graduate student may borrow up to $1,000 per year, the total not to exceed $5,000. To be eligible, a part-time graduate student must be enrolled for at least 6 credits and is limited to $500 per year. The

student is required to pay 5 per cent simple interest on the loan each year he is a borrower. No payment on the principal is due until six months after the date the student completed his course of study, with payments extended over a five-year period. Application may be made at any participating bank in Pennsylvania. For information, write to the Pennsylvania Higher Education Assistance Agency, Education Building, Harrisburg, Pa., 17126.

Residents of other states should inquire from their state education departments regarding the existence of similar plans. Some of the Eastern states having such plans are: Connecticut, Maine, Massachusetts, New Hampshire, New York, Ohio, Rhode Island, and Virginia.

ASSURED EDUCATION PLAN—The University offers to the parents (or guardians) of students the Assured Education Plan, enabling them to pay University bills out of current income on a monthly basis. It is available to parents residing anywhere in the United States. There are two plans, one covering a single year's expenses, the other covering two to five years' expenses in a single contract. Life insurance and total and permanent disability insurance are a part of the plan for a parent up to his 65th and 61st birthdays respectively.

In the one-year plan repayment may be made in 8, 10, or 12 monthly payments, the credit service charge being 2-2/3 per cent, 3-1/3 per cent, or 4 per cent respectively. The charge for the insurance is 62 cents a month for each $1,000.

Under certain conditions graduate students may sign their own agreements under the one-year plan only. The student, or spouse, if any, must be at least 21 years of age, employed, and furnish credit information. If married, the spouse must sign the agreement with the student. Repayment must be made in one year, except for terminal year students, who may have 24 months for repayment. Further information and application forms may be obtained from the Office of the Bursar.

STUDENT EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly.

A student who holds a graduate assistantship or a fellowship may not accept employment, either at the University or elsewhere, during the period of his appointment, except as stipulated in certain foundation and federal fellowship programs.

The Office of Student Aid, 218 Willard Building, offers assistance to students in finding part-time employment in town as well as on the campus.

VETERANS BENEFITS—The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws.

Under Public Law 550, a student is classified as to his rate of training on the basis of the type of program he is following and the number of credits for which he registers.

STUDENT SERVICES

HEALTH CENTER—The services of the Ritenour Health Center are available to graduate students registered for 8 or more credits and to all graduate assistants, fellows, and other holders of graduate tuition grants.

Students are entitled to five days' free treatment in the University Hospital each term. For each day of confinement in excess of five days a charge of $10 will be made. Almost all modern drugs are furnished free of charge as required for treatment, but the student may be charged extra for medication where such treatment is unusual or extremely expensive. Consult the *Manual for Graduate Students* for details concerning facilities and services.

INSURANCE PLAN—A voluntary Accident and Sickness Insurance Plan with a variety of benefits is available to graduate students and their dependents, provided

the student is eligible for the services of the Ritenour Health Center. The Undergraduate Student Government, which operates the plan, has offices in Room 203A Hetzel Union Building, University Park, Pa., 16802. Telephone: Area Code 814, 865-4952.

PLACEMENT SERVICE—The University Placement Service coordinates the placement activities of all the Colleges and the Graduate School. It is available to any student who is in need of counseling or guidance on employment problems. The services of the following sections are available to the student without charge.

The General Placement Section functions primarily as a clearing house, bringing together students, alumni, faculty members, and representatives of organizations that are seeking college-trained personnel. Summer jobs other than those at camps or resorts are listed at this office.

The Teacher Placement Section assists seniors, alumni, and graduate students in all departments in securing teaching positions.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths serve the student body. Many other religious organizations, including denominational and interdenominational groups, are active on the campus and in association with local churches.

STUDENT AFFAIRS—The Graduate Student Association is the official University-wide organization of graduate students. All students have membership in the Association, which promotes the general welfare and the academic interests of graduate students. It publishes the *Graduate School Newsletter,* helps to sponsor the Graduate School lecture series, and sponsors social functions.

MASTERS' DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees: academic and professional. Of the nine masters' degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forestry, and Master of Public Administration.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE POINT AVERAGE—A minimum grade point average of 3.0 for work done at this University is required for graduation in the case of all candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION—Adequate undergraduate preparation is required in the field in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of field and can be ascertained from the descriptive statement appearing

under the major field heading in the latter portion of this bulletin. An applicant who meets the minimum grade point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the minimum period of residence. An applicant for admission to the M.Ed. program is required to have had at least 18 credits in education and related psychology, and in certain major fields may be required to have had practice teaching.

After a student has been admitted as a regular graduate student, he should confer with the head of his major department concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department.

M.A. AND M.S.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus. A candidate must present a major and either a minor field of study or an approved group of general studies. A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to but different from that of the major. A general studies group consists of no fewer than 6 credits in fields other than that designated as the major field and considered by the major department to have significance and value for the candidate.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major field. A thesis is required of all candidates for the degree of Master of Science and of most candidates for the degree of Master of Arts. Details are given in the introductory paragraphs under the major field headings in the latter part of this bulletin. If a student is required to write a thesis, he must complete at least 6 credits of thesis research (600 or 610).

Those candidates who are not required to write a thesis must present a suitable essay or term paper. Its nature and extent shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The department may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off-campus. To do so he must make satisfactory arrangements in advance with both the major department and the Dean of the Graduate School.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

M.AGR.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Agriculture have a professional orientation and provide training for increased competence in the various fields of agriculture. They should be clearly distinguished from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which at least 12 must be in 500-level courses and the remainder in 400-level courses. A minimum of 20 credits must be earned on the University Park Campus and at least 12 must be earned outside the candidate's major field.

In addition to credit requirements, a candidate must present a paper on a selected professional problem comparable in quality to a thesis in which he applies scientific methods to the solution of a problem. Ability must be demonstrated to (a) formulate and state meaningfully the problem and objectives, (b) critically analyze the present state of knowledge of the problem, (c) acquire and analyze information to help solve the problem, (d) draw logical conclusions, and (e) intrepret the relationship between the findings and professional problems. The paper will be evaluated by a committee appointed by the Dean of the Graduate School.

The candidate is required to pass a final examination administered by a committee of three faculty members appointed by the Dean of the Graduate School with at least one member from a department other than that of the candidate's major field.

M.B.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Business Administration are designed to develop advanced professional competence in the various fields of business administration. They should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Science and Doctor of Philosophy with a major in Business Administration.

The programs require a minimum of 36 graduate credits of which at least 18 must be at the 500 level and at least 26 must be earned on the University Park Campus. Candidates who enter this program without undergraduate training in business administration may be required to take up to 21 credits of preparatory courses.

Moreover, a candidate is required to present a project paper, comparable in quality and scope of work to a graduate thesis, concerning a problem of a company.

After substantially completing his course requirements, a candidate must pass a comprehensive examination to be administered by a committee composed of graduate faculty members, the first part being written and the second part oral. During these examinations the candidate will be expected to demonstrate his ability to integrate the knowledge gained in the several functional areas of business in a manner which reflects a broad knowledge of his professional responsibilities.

Applicants for the various graduate programs in business administration are required to take the admission test for graduate study in business given by the Educational Testing Service.

M.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the several fields of education. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. The requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned on the University Park Campus and at least 24 must be in course work.

At least 15 credits in 500 series courses is required except in those fields for which the Dean has approved the waiving of this requirement for an experimental period of five years.

MAJORS IN THE FIELDS OF EDUCATION—A student may major in one of the approved fields of education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate department of education.

A program of this type requires at least 6 credits to be earned outside the fields of education.

MAJORS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as chemistry, mathematics, or German, may choose such a field as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose such a major as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major. In this case the student will be expected to choose one field in the area as a primary interest and devote at least 12 credits to it.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits will probably be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology. However, if his educational foundations background is judged to be adequate, the candidate may be approved for work in any field of education.

THESIS OR TERM PAPER—Six credits may be granted for an approved thesis. Those candidates who do not elect to write a thesis are required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department to require one or more copies of such an essay for its library or other files.

M.Eng.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which at least 12 must be earned in graduate courses (500 series), and at least 6 must be earned outside the candidate's field of concentration.

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Pennsylvania State University graduate center other than University Park.

M.F.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The program leading to the degree of Master of Fine Arts provides training for increased professional competence in the several specialized areas of the arts. It should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in Art, Music, or Theatre Arts.

A minimum of 48 credits is required to complete the program. The larger part of these credits should be above the 400 series courses. The needs of the student shall be considered in arranging the best combination of 400 and 500 series courses for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Forestry provide training for increased professional competence in the several specialized areas of forest resource management and forest products. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science with a major in forestry.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to prepare and submit an acceptable thesis. At least 6 credits of thesis work is required.

M.P.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration at local, state, national, and international levels or with private and voluntary agencies. This program should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may also specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required of which at least 6 must be devoted to either a thesis or an internship. Students with extensive government experience will write a thesis; others will serve an internship and write a critical review of the experience, the review to be comparable in quality to a thesis. A comprehensive final examination will be required of all students, the examination to be written, oral, or both.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervising committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Pennsylvania State University graduate center other than University Park.

The degree is a terminal one and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred. The two programs are recognized as different in purpose and consequently have different requirements in certain respects.

ADMISSION—A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major field in which the doctorate is offered may begin working toward a doctor's degree. However, he

has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department and is given near the end of the first, or at the beginning of the second, year of graduate work including that done for the master's degree and work done elsewhere as well as here (i.e., at about the time he has earned a total of 30 graduate credits).

A new student transferring from another graduate school with 30 or more transfer credits must take this examination before he has earned more than 10 credits here.

There are no specific admission requirements in education and related psychology for the degree of Doctor of Education unless specified by the department or committee in charge of the particular major field.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure the attainment of the doctorate. The general requirements are based upon a period of residence, the passing of comprehensive examinations, and the writing of a satisfactory thesis. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE POINT AVERAGE—A minimum grade point average of 3.0 for work done at this University is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later.

TIME LIMITATION—A student who was formally accepted as a doctoral candidate on or after June 1, 1963, is required to complete his program within seven years from the date of his acceptance as a candidate. A student who was admitted to doctoral candidacy, formally or informally, prior to June 1, 1963, is required to complete his program before July 1, 1971.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research, or their equivalent in credits, is required for a doctor's degree. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study. The D.Ed. candidate may meet the residence requirement by enrollment in the summer terms, but increasingly departments are insisting upon the same requirements as for the Ph.D.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term and three such terms will meet the minimum residence requirement for the Ph.D.

OFF-CAMPUS AND TRANSFER CREDITS—A maximum of two full academic years of work in another approved school granting the doctorate in the major field may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. Not more than one year of work at a graduate school not granting the doctorate in the major field will be accepted here to apply toward doctoral degree requirements. Credit for courses and research work done elsewhere can be used to meet degree requirements, however,

only if the work is appropriate to the candidate's proposed program of study as determined by his doctoral committee.

By securing the maximum allowable number of transfer credits, it is possible theoretically to complete the requirements at this institution in three terms. In practice, however, this is rarely possible because of the sequence required in courses and examinations, special departmental requirements, and the possibility of protracted research. It must be remembered that the quality of the program rather than the time requirement is of paramount concern.

Subject to the approval of his adviser, the head of his major department, and the Dean of the Graduate School, a student may register for research to be done away from the University Park Campus. Such work will not be approved, however, simply because the arrangement is convenient for the student; scholarly considerations must determine the choice of location. A doctoral candidate may register for a maximum of 30 credits of research in absentia, but these credits must be included in the 60 credits which a candidate may earn in study away from the University Park Campus. The maximum load permitted a student who is employed full time is 4 credits in a term.

With the approval of his committee, a candidate may apply toward the minimum requirements of a doctor's degree a maximum of 10 credits earned in Continuing Education classes or at the Commonwealth Campuses of The Pennsylvania State University. Credits so earned as a part of a master's degree program must be included in the limit of 10.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted as a regular graduate student, he should confer with the head of his major department concerning departmental procedures and the appointment of an adviser. The arrangement and approval of the details of the term-by-term schedule of the student is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major department for this specific duty.

The general guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of five or more members of the Graduate Faculty. The committee is appointed by the Dean of the Graduate School, upon recommendation of the head of the major department, at the time the student is admitted to candidacy. The chairman of the committee must hold senior membership in the Graduate Faculty. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. At his discretion, the Dean may add other members to the committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after admission to candidacy. The committee will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

LANGUAGE EXAMINATIONS—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School and must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must show either a reading knowledge of two other languages or a reading, writing, listening, and speaking knowledge of one other language. The languages used to satisfy this requirement must have significance in the candidate's field of study and

be approved by the candidate's doctoral committee and the Dean of the Graduate School. French, German, and Russian are the languages most frequently needed and will be approved by the Dean without specific request. The use of any other language must be approved in advance.

When competence in two languages is offered in fulfillment of the requirements, the student is urged to complete one-half of the requirement before admission to candidacy and is required to complete the whole requirement before taking the comprehensive examination. If the candidate elects to demonstrate a reading, writing, listening, and speaking knowledge of one language, he is required to demonstrate competence in two of the four skills before admission to candidacy and in all four before taking the comprehensive examination.

Registration for both types of examination occurs at the beginning of the term, the specific date being given in the calendar. An applicant for an examination in reading competence is required to present himself to the language department concerned for a preliminary test in oral translation, not to exceed 15 minutes' duration during the registration period of one of the terms. A student who makes a very poor showing in the preliminary test will not be permitted to register for the next examination and may be required to take another preliminary test.

The examinations in reading competence are administered by the respective language departments and are held four times each year. Specific dates may be obtained from the calendar. The examination, which is to be written and to be completed with the aid of a dictionary, is one hour in length. The text for translation shall be a periodical article selected by the examining department from five articles in the candidate's field of specialty and recommended by his adviser or department head. Each of the articles recommended shall be not less than 500 words in length.

Administration of the examinations designed for demonstration of a reading, writing, listening, and speaking knowledge of a language other than English is vested in two members of each of the foreign language departments. Immediately upon registration the candidate is assigned by the examiners a work of considerable length unrelated to the area of his specialty; discussion of this work with the examiner six weeks later in the language in which it is written will serve to determine the candidate's broad, idiomatic grasp of the language. Subsequently, the candidate will be required without prior preparation to write in the same language a summary of the contents of a shorter document in the area of his specialty. For this purpose his adviser or department head is expected to recommend to the examiners five articles of at least 500 words in length, the titles of which are not known to the student, from which they will select the one to be employed. All arrangements for the examination are to be made in the language in which competence is to be demonstrated.

In general, the language rqeuirements must be met at this University. However, if a student has passed suitable language proficiency examinations at another institution prior to admission to the Graduate School at Penn State, this may be accepted under certain circumstances in satisfaction of requirements here. A letter of certification from the Graduate Dean of the other institution will be required.

Candidates for the D.Ed. degree may be required by their major departments to demonstrate competency in foreign languages, but there is no Graduate School requirement.

COMPREHENSIVE EXAMINATIONS—A candidate for the Ph.D. or D.Ed. degree is required to take a comprehensive examination covering his major and minor fields to determine if he has adequate mastery of the subject matter to entitle him to proceed to the completion of a thesis.

This examination will normally be taken when the candidate has substantially completed his course work. It is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. In no case may the final examination be scheduled less than three months after the com-

prehensive examination. The comprehensive examination is given and evaluated by the doctoral committee and may be either written or oral, or both. A favorable vote of at least two thirds of the members of the committee is required for passing. In case of failure, it is the responsibility of the doctoral committee to determine whether he may take another examination. The results are reported to the Dean of the Graduate School.

All candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later are required to have a minimum grade point average of 3.0, for work done at this University, at the time the comprehensive examination is given.

A candidate for the degree of Doctor of Philosophy must have satisfied the language requirements before taking the comprehensive examination.

FINAL ORAL EXAMINATIONS—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. In no case may the final examination be scheduled less than three months after the comprehensive examination. The deadline for holding the examination is three weeks before Commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the whole field of study of the candidate without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

MINOR FIELDS—A minor is not required of all candidates for the Ph.D. degree. A department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and the minor fields.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal on the part of the candidate an ability to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than two weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate, such as biological science, foods and nutrition, or English.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) the satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

MAJOR AND MINOR FIELDS—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major field of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education.

A candidate choosing a major in one of the fields of education must also choose either a minor or a group of general studies with the approval of the major department. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside the fields of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside the fields of education considered by the major department to have significance and value for the candidate.

COMPREHENSIVE EXAMINATIONS—In addition to demonstrating a high level of competence in the subject matter of his major and minor fields, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later are required to have a minimum grade point average of 3.0, for work done at this University, at the time the comprehensive examination is given.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. The thesis may be based upon a product or project of a professional nature, provided that scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a writ-

ten discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than two weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

PROGRAMS AND COURSES

Programs of study leading to advanced degrees are offered in many major and minor fields. These are listed in the following section, and the major fields are summarized at the beginning of the following section. Related courses are grouped together under the name of the field. To locate a particular course or group of courses, consult the index.

In general, departments of the University are identified with specific major fields. Thus aeronautical engineering is a major field of study which is offered under the supervision of the Department of Aeronautical Engineering. On the other hand, biological science and comparative literature are major fields for which there are no corresponding departments. In such cases a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one field. Thus the Department of Civil Engineering offers work in both civil and sanitary engineering.

Applicants for admission are encouraged to consult the person whose name is listed under the major field heading.

DEGREES—In those major fields approved for the doctorate, the Ph.D. is normally conferred, although a program leading to the D.Ed. may also be arranged with the consent of the department or committee in charge if such a professional program is appropriate. Similarly, in major fields approved for the master's degree the M.A. or M.S. is normally conferred, but a program leading to the M.Agr., M.B.A., M.Ed., M.Eng., M.F., M.F.A., or M.P.A. may also be available. The D.Ed. and M.Ed. are not limited to the fields of education, but with the consent of the department or committee in charge may be offered in any approved major field appropriate to the preparation of teachers, such as mathematics or English. In this case the program is sponsored by a major department outside the fields of education, such as the Department of Mathematics, but the student's minor is in education.

MINOR FIELDS—All major fields listed are also acceptable as minors. In addition, a few fields in which no advanced degrees are offered have been approved as minors for candidates who are majoring in related areas. Such minor fields are identified in the summary at the beginning of the following section and by a brief statement under the field heading in that section.

A candidate's choice of minor field depends upon the particular degree he is seeking and is subject to the approval of his major department. The requirements in each minor field are established by the minor department subject to the regulations of the Graduate Faculty.

INTERDISCIPLINARY MAJORS—In addition to the majors listed on the following pages, interdisciplinary majors involving two or more departments may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental committees.

OTHER FIELDS—Fields which have not been approved for either major or minor work, but in which approved courses are offered, are listed at the end of this

bulletin. These courses may be used in graduate programs as electives or as part of a general studies program, subject to the approval of the major department and to the restrictions upon the use of 400 series courses in degree programs.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 46 to 50 under the specific requirements for the various masters' degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.5, and other students who have been granted permission to enroll by the Dean of the Graduate School.

Course numbers 600 and 610 apply to thesis research and are available only to students registered in the Graduate School.

CREDITS—A credit is defined as a unit of time approximately equivalent to one week of full-time graduate study. Accordingly, a full-time student having no concurrent employment may earn a maximum of 10 credits in a 10-week term. A "credit" as used in this bulletin, therefore, is identical in meaning with a "semester credit" and should not be confused with a "quarter credit" which is associated with the traditional quarter system. By increasing the length of class periods to 75 minutes, the Penn State calendar based upon a 10-week term provides for the same amount of time in a given course as does the typical semester plan.

COURSE DESCRIPTIONS—A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department offering the course.

A department may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400 and 500 series courses a department may schedule an individual student for fewer credits than the maximum number but in no case for more than the maximum number authorized.

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Timetable,* which is available at nominal cost from the Scheduling Office approximately six months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

RESEARCH AND THESIS WORK—In general, students registering for work on a master's or a doctor's thesis will, if it is to be done on the University Park Campus, use course number 600 preceded by an abbreviation designating the major field. Thus Aro.E. 600 signifies thesis research in aeronautical engineering. In case such work has been authorized for students not working on the University Park Campus, the number 610 will be used. Credits will be 1 to 10 per term.

It should be assumed that the numbers 600 and 610 are available in all fields in which majors have been approved for advanced degrees although these numbers may not appear in the timetables.

MAJOR and MINOR FIELDS

GRADUATE FIELDS OF STUDY

Aeronautical Engineering—Ph.D., M.S.
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—M.S.
Agronomy—Ph.D., M.S., M.Agr.
Animal Industry—Ph.D., M.S.
Animal Nutrition—Ph.D., M.S.
Anthropology—Ph.D., M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A.
Art Education—Ph.D., D.Ed., M.S., M.Ed.
Art History—M.A.
Biochemistry—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Business Education—Ph.D., D.Ed., M.S., M.Ed.
Ceramic Technology—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S.
Chemistry—Ph.D., M.S., M.Ed.
Child Development and Family Relationships—Ph.D., D.Ed., M.S., M.Ed.
Civil Engineering—Ph.D., M.S., M.Eng.
Clothing and Textiles—Ph.D., D.Ed., M.S., M.Ed.
Comparative Literature—Ph.D., M.A.
Counselor Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Earth Sciences—M.Ed.
Economics—Ph.D., M.A.
Educational Administration—Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology—Ph.D., M.S.
Electrical Engineering—Ph.D., M.S., M.Eng.*
Elementary Education—Ph.D., D.Ed., M.S., M.Ed.
Engineering Mechanics—Ph.D., M.S., M.Eng.
Engineering Science—M.Eng.
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S., M.Agr.
Extension Education—M.Agr., M.Ed.
Family Economics and Home Management—Ph.D., D.Ed., M.S., M.Ed.
Food Service and Housing Administration—M.S., M.Ed.
Foods and Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Forestry—M.S., M.F.
French—Ph.D., D.Ed., M.A., M.Ed.
Fuel Technology—Ph.D., M.S.
General Family Studies—Ph.D., D.Ed., M.S., M.Ed.
Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed., M.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Art (minor only)
Home Economics Education—Ph.D., D.Ed., M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—M.S., M.Eng.
Journalism—M.A.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.*
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Preparation—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S.
Music—M.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., D.Ed., M.S.
Public Administration—M.P.A.
Recreation Education—M.S., M.Ed. (See p. 155)
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
Solid State Technology—Ph.D., M.S.
Spanish—Ph.D., D.Ed., M.A., M.Ed.
Speech—Ph.D., D.Ed., M.A., M.Ed.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics (minor only)
Theatre Arts—M.A., M.F.A.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

The degrees listed above are the ones normally conferred in each of the designated major fields. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above fields in which a master's degree is conferred provided the field is appropriate to the preparation of teachers.

*Not offered on the University Park Campus.

Courses in Major and Minor Fields

AERONAUTICAL ENGINEERING

GEORGE F. WISLICENUS, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Lumley, McCormick, and Wislicenus; Associate Professors Holl and Sevik; Assistant Professors Hoult and Rodgers.

Opportunities are available for graduate study in the following and related areas: modern fluid mechanics and physics, the interaction of fluids with solids, and the application of these disciplines to the design of devices and to the environment in which they operate. These topics are specifically included: cavitation, magnetohydrodynamics, rarified gas dynamics, the stability of laminar motions, turbulence, aero- and hydroelasticity, stability and control of vehicles, turbomachinery, V/STOL aircraft, high lift devices, and ground effect machines.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so.

AERONAUTICAL ENGINEERING (ARO E)

401a,b,c. AERONAUTICAL ENGINEERING PROJECTS (2-12)
402. AEROSPACE DESIGN (2)
407. AERODYNAMICS OF V/STOL AIRCRAFT (3)
410. AIRCRAFT AND SPACE PROPULSION (3)
411. AEROELASTICITY (3)
412. AERODYNAMICS OF VISCOUS FLUIDS (3)
413. STABILITY AND CONTROL OF AIRCRAFT AND MISSILES (3)
414. ADVANCED GASDYNAMICS (3)
415. ADVANCED THEORETICAL FLUID DYNAMICS (3-6)
416-417. AEROSPACE UNDERGRADUATE THESIS (2 each)
418. AEROSPACE SYSTEMS ENGINEERING (3)
420. PRINCIPLES OF FLIGHT TESTING (3)

503. ELECTROMAGNETICALLY AND CHEMICALLY ACTIVE FLOWS (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. AERODYNAMICS OF V/STOL AIRCRAFT (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aro.E. 407.

505. AERO- AND HYDROELASTICITY (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. CAVITATION (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. THEORY AND DESIGN OF TURBOMACHINERY (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Perfect Fluid Theory A (3) Mathematical review, equations of motion and general consequences, application of complex variables to two-dimensional flow, conformal representations, Stokes' stream function.

509. Perfect Fluid Theory B (3) Review of axisymmetric motion; two-dimensional vortex motions; motions with cylindrical, spherical geometry; Bessel, Legendre functions; vortex motions in space. Prerequisite: Aro.E. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory, Prandtl-Meyer flow, method of characteristics.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

520. Selected Topics in Aeronautical Engineering (1-12)

AGRICULTURAL ECONOMICS

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Barr, Becker, Bennett, Brandow, Butz, Frey, Hutton, McAlexander, Pasto, Pierce, Southworth, and Trotter; Associate Professor Stemberger.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

AGRICULTURAL ECONOMICS (AG EC)

407.	Advanced Farm Management (3)	*Mr. Hutton*
420.	Agricultural Prices (3)	*Mr. Bennett*
421.	Land Economics (3)	*Mr. Frey*
426.	(A.I. 426) Livestock Marketing (3)	*Mr. Trotter*

500. Seminar in Agricultural Economics (1-6) Review of current literature and problems.

503. Research Methods in Farm Management (1-3) Evaluation of research procedures, methods, results, and needs in the field; emphasis on their application to specific research problems. Prerequisites: Ag.Ec. 6, Econ. 14. *Mr. McAlexander*

504. Agricultural Price and Income Policy (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy making. Prerequisites: Ag.Ec. 420, Econ. 405. *Mr. Brandow*

505. Advanced Agricultural Statistics (3) Multiple correlation, curve fitting, analysis of variance, selection of samples, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

506. Economic Problems in Marketing Specific Agricultural Products (3) Profit maximization; psychological and sociological aspects of selling; engineering aspects of cost reduction; techniques in developing information for managerial decisions.

507. Seminar in Farm Management (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

510. Advanced Farm Finance (1-3) Problems and policies in agricultural credit, insurance, and farm financial management. *Mr. Hutton*

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. *Mr. Brandow*

522. Advanced Farm Appraisal (2) Land value theory; methods of land valuation; field practice in farm appraisal. *Mr. Pasto*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences.

526. Research Methods in Agricultural Economics (2) Application of economic and statistical principles.

534. Agricultural Production Economics (3) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. *Mr. McAlexander*

535. Seminar in Agricultural Marketing (2) *Mr. Southworth*

536. Seminar in Dairy Economics (1 per term) *Messrs. Pierce and Butz*

AGRICULTURAL EDUCATION

David R. McClay, *Head of the Department*
101 Agricultural Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors McClay and Stevens; Associate Professor Hoover.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, and teacher education in agricultural education and related fields. Minors may be taken in any of the areas of agricultural science, technology, and business. Programs may include courses needed for certification in other fields of education.

AGRICULTURAL EDUCATION (AG ED)

418v. Survey of Vocational Education in Agriculture (1-3) *Mr. Hoover*
420v. Advanced Visual and Other Sensory Aids in Teaching Agriculture (1-6) *Mr. Anthony*
422v. Supervision of Vocational Education in Agriculture (1-3) *Mr. Anthony*
424v. Occupational Guidance in Agricultural Industry (1-4) *Mr. Hoover*
426v. Young and Adult Farmer Education in Vocational Agriculture (1-4) *Mr. Stevens*
434v. Agricultural Developments (1-6) *Mr. Love*

501v. History of Agricultural Education (1-3) Development of training for agricultural vocations; emphasis upon introduction of agricultural instruction into the high school program. *Mr. Hoover*

502v. Teaching Vocational Agriculture (1-3) Organization of instruction with respect to vocational objectives, methods of presentation, supervision of practice, pupil evaluation of goals, and follow-up. *Mr. Stevens*

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation. *Mr. Stevens*

504v. Agricultural Education Seminar (1 per term) *Mr. McClay and Staff*

508v. State and County Administration and Supervision of Agricultural Education (1-3) Organization and administration of state, county, township, and district systems of agricultural education; state and federal legislation. *Mr. McClay*

509v. Teacher Training in Agricultural Education (1-6) Construction of college curriculums, courses of study, and organization of college departments for training agricultural teachers. *Mr. McClay*

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education. *Mr. Stevens*

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems. *Mr. Stevens*

524v. Annual Plan of Work (1-3) Detailed study of the agricultural education needs of each student's community and outlining annual plans of work. *Mr. Hoover*

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, technique of teaching, and measurements of results of teaching. *Mr. McClay*

AGRICULTURAL ENGINEERING

Frank W. Peikert, *Head of the Department*
204 Agricultural Engineering Building

Degree Conferred: M.S.
Graduate Faculty: Professors Bartlett, Mohsenin, and Peikert; Associate Professor Aldrich.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; and rural sanitation and conservation engineering.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, solar poultry houses and plant growth structures for modified atmosphere, and a laboratory for research on mechanical and rheological properties of agricultural materials. This laboratory is equipped with an Instron testing machine with a complete line of accessories including an environmental chamber and the Instron Rheometer for research on rheology of foods and agricultural materials.

Prerequisite to major work is the completion of an undergraduate engineering curriculum.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Farm Structures (3)
404. Farm Machinery (3)
405. Advanced Farm Electrification (3)
406. Advanced Dairy Engineering (3)
407. Soil Water Engineering (3)
410. Farm Power (3)
420. Seminar (1)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY

Walter I. Thomas, *Head of the Department*
118 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Fortmann, Higbee, Hunter, Kardos, Matelski, Raleigh,

Richer, Sprague, Thomas, and Washko; Associate Professors Cleveland, Duich, Marriott, Pfeifer, and Starling; Assistant Professors Baker, Gorsline, Harrington, Johnson, Marshall, and McKee.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures. Facilities are available for X-ray diffraction, infrared and petrographic investigations of soils.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

AGRONOMY (AGRO)

411. Breeding of Field Crops (3) *Mr. Thomas*
416a. Soil Characterization and Classification—Lecture (4) *Mr. Higbee*
416b. Soil Characterization and Classification—Practicum (1) *Mr. Higbee*
417. Forest Soils (3) *Mr. Matelski*
419. Soil Properties (4) *Mr. Baker*
422. Soil Conservation (3) *Mr. Kardos*
423. Pasture and Grassland Management (3) *Mr. Washko*
424. Fertilizer Technology (3) *Mr. Marriott*
425. Principles of Field Crop Production (3) *Messrs. Pfeifer and Gorsline*
431. Soil Fertility and Management (3) *Mr. Marriott*
438. Principles of Weed Control (3) *Mr. Raleigh*
490. Agronomic Problems (1-6) *Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Bot. 406. Winter term, odd years. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 417 or Chem. 23. Spring term, even years. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Phys. 215, Bioch. 425. Fall term, even years. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Bot. (Zool.) 422. Fall term, even years. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization and their applications to plant breeding. Prerequisite: Bot. (Zool.) 422. Fall term, odd years. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Math. 8 or Ag. 400. Fall term. *Mr. Starling*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. Winter term, odd years. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisite: Agro. 28, Bot. 406. Winter term, even years. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Bot. 406. Spring term, odd years. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 1, Chem. 13, G.Sc. 1. Winter term, even years. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. Winter term. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1-8 per term)

ANIMAL INDUSTRY

Russell C. Miller
Head of the Department of Animal Industry and Nutrition
202 Armsby Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bortree, Henning, and Miller; Associate professor Gobble; Assistant Professor Sherritt.

A student may specialize in animal production, animal breeding, and meats. The prerequisite for admission is the completion of an undergraduate major in animal husbandry or a related animal science area. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite course without degree credit.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Husbandry Seminar (1)
426. (Ag.Ec. 426) Livestock Marketing (3)
431. Advanced Meat Selection and Grading (2)

500. Seminar in Animal Industry (1-6)

*Credits 1-6 per term.

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

503. Livestock Management (3) Handling of purebred herds and flocks; relation of livestock breeders to the public and methods of developing purebred herds and flocks through careful breeding.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANIMAL NUTRITION

Russell C. Miller
Head of the Department of Animal Industry and Nutrition
202 Armsby Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Barron, Bratzler, and Miller; Associate Professors Cowan, Hartsook, and Hershberger; Assistant Professor Long.

General nutrition, including energy metabolism, is emphasized in the graduate programs. For admission a student must have had courses in nutrition, organic chemistry, analytical chemistry, and calculus; and he must have had a total of at least 20 credits in chemistry and physics.

ANIMAL NUTRITION (A NTR)

401. Physiology of Nutrition (3) *Mr. Hartsook*
402. Energy and Protein Metabolism (3) *Mr. Hartsook*

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY

Paul T. Baker
Acting Head of the Department of Sociology and Anthropology
240 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Baker, Carpenter, F. R. Matson, and Mook; Associate Professor Sanders.

Undergraduate preparation for this field must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences. With special permission exceptional students will be admitted provided they make up course deficiencies without graduate credit.

Sociology may be chosen as a minor field by students majoring in anthropology.

A thesis is required of all M.A. candidates in this field.

ANTHROPOLOGY (ANTHY)

401. Human Evolution (3)
402. Human Ecology (3)
420. Archaeology of the Near East (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
440. Ethnology of South America (3)
443. Ethnology of the Old World (3-6)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
450. Primitive Society (3)
451. Economic Anthropology (3)
455. Culture and Personality (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Applied Anthropology (3) Methods and results of studies in which anthropological theory was applied to current problems in human biology and culture.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

530. Individual Study in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-6) Individual field work in any aspect of anthropology, supervised by staff of professorial rank.

562. Laboratory Methods in Anthropology (3-6) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

ARCHITECTURAL ENGINEERING

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.
Graduate Faculty: Professor Richardson; Associate Professor Albright.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems. and integrated engineering requirements for protective construction.

For admission a student must have a strong background in some field of engineering: in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)
430. Architectural Engineering (3)
431. Architectural Engineering (3)
432. Architectural Engineering (4)
433. Architectural Engineering Thesis (2)
434. Architectural Engineering Thesis (2)
435. Architectural Engineering Thesis (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)
445. Architectural Engineering Seminar (1-6)
451. Fundamentals of Nuclear Defense Planning and Design (3)
464. Advanced Architectural Illumination Systems Design (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.
Mr. Richardson and Staff

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar. *Mr. Richardson and Staff*

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems. Prerequisite: graduate standing.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers. Prerequisite: graduate standing.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5, 451; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6) Prerequisite or concurrent: A.E. 451.

ARCHITECTURE

GREGORY AIN, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.
Graduate Faculty: Professor Hallock.

For admission, a degree of Bachelor of Architecture, Bachelor of Science in Architecture, or Bachelor of Fine Arts in a five-year curriculum in architecture is required.

ARCHITECTURE (ARCH)

411. ADVANCED ARCHITECTURAL DESIGN (6)
412. ADVANCED ARCHITECTURAL DESIGN AND THESIS (5)
413. ADVANCED ARCHITECTURAL DESIGN AND THESIS (5)

501. ARCHITECTURAL DESIGN (4-8) Problems in advanced planning and design, including study of group composition. Practicum and seminar.

502. ARCHITECTURAL RESEARCH (2-12) Prosecution of assigned problems under the guidance of an instructor.

ART

WIRTH V. MCCOY, *Head of the Department*
106 Temporary Building

Degree Conferred: M.A.
Graduate Faculty: Professors Heller and Zoretich; Associate Professors Altman, Pappas, and Shobaken.

Students may specialize in painting, printmaking, sculpture, or design. For admission at least 24 credits in studio art are required, and a portfolio of work must be presented. If an inadequacy exists in the student's undergraduate preparation, he will be required to make up the deficiency without degree credit.

A thesis is required of all M.A. candidates in this major.

ART (ART)

400. ADVANCED OIL PAINTING (3-12)
410. WATER-COLOR PAINTING: LANDSCAPE, STILL LIFE, AND FIGURE (3-9)
420. APPLIED DESIGN (3-9)
431. SCULPTURE (2-6)
440. PRINTMAKING (2-6)
490. LIFE DRAWING (3)

500. ART RESEARCH (2-6) Prosecution of assigned problems under the guidance of an instructor.

510. ADVANCED PAINTING (2-12)

531. ADVANCED SCULPTURE (2-12)

540. ADVANCED PRINTMAKING (2-12)

ART EDUCATION

EDWARD L. MATTIL, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Beittel and Mattil; Associate Professors Cataldo, Chomicky, Edmonston, and Pappas.

Graduate programs in this field prepare students for careers in public school art teaching, art supervision, college teaching, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree.

ART EDUCATION (A ED)

404. METHODS OF GRAPHICS AND ILLUSTRATIONS (3)
414. ADVANCED CRAFTS FOR TEACHERS (3-6)
420. CERAMICS FOR TEACHERS (3)
434. ART APPRECIATION IN THE EDUCATIONAL PROGRAM (3)
435. ART IN THE ELEMENTARY SCHOOL (3)
436. ART IN THE SECONDARY SCHOOL (3)
486. CURRENT PROBLEMS IN ART EDUCATION (2-3)
487. MURAL PAINTING IN SCHOOLS (3)
488. ADVANCED MURAL PAINTING IN SCHOOLS (3)
489. ART EXPERIENCES WITH CHILDREN (3)

501. SEMINAR IN ART EDUCATION (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. ADVANCED METHODS IN GRAPHIC PROCESSES (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. FUNCTIONAL RELATIONSHIPS IN CRAFTS (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. ANALYSIS OF THREE-DIMENSIONAL PROCESSES IN ART (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. ADVANCED CERAMIC ART (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

534. CREATIVE ART ACTIVITY FOR THE HANDICAPPED (3) Specific methods for development of creative art activity with the physically, mentally, emotionally, and socially handicapped; adjustive effect upon them. Prerequisite: 6 credits in art education or 6 in special education or 6 in psychology.

535. ADMINISTRATION AND SUPERVISION OF ART EDUCATION PROGRAMS (3) The prob-

lems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

598. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

599. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 level, including A.Ed. 598.

ART HISTORY

Winston R. Weisman, *Head of the Department*
116 Sackett Building

Degree Conferred: M.A.
Graduate Faculty: Professors Enggass, Hyslop, and Weisman; Assistant Professor Mauner.

For admission at least 18 credits of undergraduate work in art are required. If an inadequacy exists, the student will be required to make up the deficiency without degree credit. Prior to graduation the candidate must demonstrate a working knowledge of at least one foreign language in his area of study.
A thesis is required of all M.A. candidates in this major.

ART HISTORY (ART H)

403. Studies in the Arts of the Middle Ages (3)
404. Theory and Form in Mannerist Art (3)
406. Movements in 19th Century European Art (3)
407. American Art of the Early Republic (3)
408. American Art from the Centennial to the Armory Show (3)
409. Movements in Contemporary Art (3-6)
410. Taste and Criticism in Art (3)
413. Problems in Art History (3-6 per term)
421. Contemporary Architecture (3)
448. History of Prints and Drawings (3)

502. Seminar in Medieval Art (3-6) Original research into problems dealing with the art of the middle ages.

503. Art History Research (3-6) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

504. Seminar in Renaissance Art (3-6) Investigations in the area of Renaissance art, centering around major masters and monuments.

505. Seminar in Baroque Art (3-6) Investigations in the area of Baroque art centering around major masters and monuments.

506. Seminar in Modern Art (3-6) Lectures, readings, reports, and discussions in the field of modern art.

507. Seminar in Modern Architecture (3) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

508. Seminar in American Art (3-6) Studies in the field of American art involving original research.

ART—MUSIC—THEATRE (A M T)

400. Contemporary Forms in Art, Music, Theatre (3)

BIOCHEMISTRY

Howard O. Triebold, *Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Clagett, Guerrant, Mallette, Pritham, Sullivan, and Triebold; Associate Professor Shigley; Assistant Professors Loerch, Mumma, and Payne.

Opportunities for research and graduate study are available in plant metabolism and photosynthesis, intermediary metabolism, nucleic acids, proteins, carbohydrates, lipides, enzymes, vitamins and nutrition, clinical chemistry, endocrinology, and pesticides.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

BIOCHEMISTRY (BIOCH)

401. General Biochemistry (4) *Mr. Clagett*
402. General Biochemistry (4) *Mr. Clagett*
404. Food Chemistry (3-4) *Mr. Triebold*
417. Biochemical Methods of Analysis (4) *Mr. Loerch*
425. Biophysical Chemistry (4) *Mr. Mumma*
426. Biocolloids (3) *Mr. Mallette*
436. Physiological Chemistry (3) *Mr. Pritham*
437. Physiological Chemistry (3) *Mr. Pritham*
438. Clinical Methods (3) *Mr. Pritham*
439. Problems in Biochemistry (1-12)

501. Enzymes (2) Investigations and theories concerning nature of enzymes, enzyme action, influence of chemical environment on enzyme action, and biological applications. Prerequisite: Bioch. 402 or 437. Fall term. *Mr. Clagett*

503. Biochemical Problems (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

505. Vitamins and Dietary Deficiency Diseases (2) Lectures, conferences, and assigned reading. Prerequisite: Bioch. 402 or 437. Fall term, odd years.
Mr. Guerrant

507. Seminar in Biochemistry (1 per term)

510. Proteins, Amino Acids, and Peptides (2) Organic, physical, and biological chemistry of the naturally occurring compounds of this group. Prerequisites: Bioch. 425; 402 or 437. Fall term. *Mr. Mallette*

511. Carbohydrates (2) Chemical constitution and properties of carbohydrates; their metabolism in plant and animal organisms. Prerequisite: Bioch. 402 or 437. Spring term. *Mr. Mumma*

512. Lipides (2) Investigations on biochemistry of fats and related substances. Winter term. *Mr. Shigley*

516. Chemistry of the Pesticides (2) Lectures and assigned readings on the chemistry of insecticides, fungicides, herbicides, rodenticides, and related materials. Prerequisites: Chem. 31; Bioch. 402 or 437. Winter term, even years.

517. Endocrine Secretions (2) Chemistry of hormones and their physiological significance. Prerequisite: Bioch. 402 or 437. Spring term, even years. *Mr. Pritham*

519. Intermediary Metabolism (3) Processes involved in the utilization of metabolites in plants and animals. Prerequisite: Bioch. 402. Spring term. *Mr. Mallette*

520. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on proteins and enzymes. Prerequisite or concurrent: Bioch. 501, 510. Fall term. *Messrs. Clagett and Mallette*

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipides and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512. Winter term. *Messrs. Shigley and Mumma*

BIOLOGICAL SCIENCE

Leon R. Kneebone, *Chairman of the Committee on Biological Science*
117 Buckhout Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biophysics, botany, entomology, genetics, microbiology, plant pathology, and zoology.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including at least one year of chemistry. In addition, 18 credits in education and related psychology are required for admission to the M.Ed. program. As many as 6 credits may be made up as undergraduate deficiencies after the candidate is admitted to the Graduate School.

The candidate for the M.Ed. degree must earn at least 24 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in educational foundations and a term paper are required.

The D.Ed. program, designed for secondary school and college science teachers, requires a minimum of 60 credits in natural science of which at least 45 must be in biological science. A minimum of 15 credits each is required in professional education and in thesis research. In addition, a reading knowledge of one foreign language is required.

BIOPHYSICS

ERNEST C. POLLARD, *Head of the Department*
101 Walker Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professor Pollard; Associate Professors Deering, Ginoza, Person, H. Schraer, Smythe, and Strother; Assistant Professors R. Schraer and Taylor.

This program is designed for those interested in applying physical methods to the problems of living systems. A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. Opportunity to make up possible undergraduate deficiencies is provided in the program.

Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by the faculty. These include courses in physics, chemistry, biochemistry, zoology, botany, and microbiology.

BIOPHYSICS (BPHYS)

410. Special Topics (1-6)
473-474. BIOPHYSICS (3 each)

580. BIOPHYSICAL SCIENCE (3) Theory of muscular contraction, heart action, and nerve conduction; X-ray analysis of proteins and nucleic acids; enzyme kinetics and thermodynamics.

581. RADIATION BIOPHYSICS (2) The action of ultraviolet and ionizing radiation and of radioactive decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 474.

582. BIOPHYSICS OF NUCLEIC ACIDS (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

583. SPECIAL TOPICS IN BIOPHYSICS (1-6 per term)

584. SEMINAR IN BIOPHYSICS (1 per term)

585. ELECTRON MICROSCOPY IN BIOLOGICAL SCIENCE (3) Principles of electron microscopy and application of techniques for the study of the ultrastructure of biological materials. Prerequisite: any of the following—Bphys. 473, Zool. 437, Bot. 405, Micrb. 401.

BOTANY

ALVIN R. GROVE, *Acting Head of the Department*
206 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Fergus, Grove, Grun, Kneebone, Wahl, and Wright; Associate Professors Hill, Hillson, Kovar, and Schein; Assistant Professors Bell, Hamilton, Hovin, and Pursell.

An entering student should present 27 credits of undergraduate work in botany or 21 credits in botany and related biological science. A strong background in chem-

istry, physics, and mathematics is desirable. As many as 6 credits may be made up as undergraduate deficiencies after the candidate has been admitted to the Graduate School.

See also "Plant Pathology" and "Genetics."

BOTANY (BOT)

400.	Comparative Plant Morphology (4)	*Mr. Hillson*
403.	Plant Biology for Teachers (3)	*Mr. Westerfeld*
404.	Plant Biology for Teachers (3)	*Mr. Westerfeld*
405.	(Zool. 405) General Cytology (3)	*Mr. Grun*
407.	Plant Anatomy (3)	*Mr. Hillson*
409.	Plant Ecology (3)	*Mr. Kovar*
414.	Taxonomy of Vascular Plants (3)	*Mr. Wahl*
419.	Mycology (3)	*Mr. Fergus*
421.	Botanical Technique (3)	*Mr. Pursell*
422.	(Zool. 422) Advanced Genetics (3)	*Messrs. Wright and Grun*
441.	Plant Physiology (3)	*Mr. Bell*
442.	Plant Physiology (3)	*Mr. Bell*
443.	Plant Physiology (3)	*Mr. Bell*

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Winter term. *Mr. Bell*

501. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years. *Mr. Fergus*

505. (Zool. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Bot. (Zool.) 405 or 422. Spring term, odd years. *Mr. Grun*

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Bot. 407. Spring term, even years. *Mr. Hillson*

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration, and catabolism. Prerequisite: Bot. 406. Fall term. *Mr. Hamilton*

512. Advanced Plant Physiology (3) Continuation of Bot. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Bot. 406. Winter term. *Mr. Hamilton*

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Prerequisite: Bot. 409. Winter term, odd years. *Mr. Kovar*

518. Special Problems (1-12) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

521. Medical and Industrial Mycology (3) Structure, life histories, classification, and techniques of study of the fungi pathogenic to man and of fungi important in industry. Fall term, odd years. *Mr. Fergus*

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy,

phylogeny, and life histories; identification and field work. Prerequisite: Bot. 419. Winter term, even years. *Mr. Fergus*

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Bot. 419. Spring term, even years. *Mr. Fergus*

524. (Zool. 524) Seminar in Genetics (1 per term) *Messrs. Wright and Grun*

528. (Zool. 528) Population Genetics (3) Factors affecting gene frequency, genotype frequency, genotype-environmental interaction, and genetic relationship in natural and artificial populations. Winter term, even years.

533. (Zool. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years. *Mr. Grove*

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seed and fruit development. Winter term, even years. *Mr. Grove*

537. (Sec.Ed. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

538. Botany Seminar (1 per term) Presentation and discussion of selected topics.

539. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years. *Mr. Pursell*

540. Algology (4) Comparative morphology, taxonomy, and ecology of fresh water and marine algae; culturing, collection, preservation techniques. Prerequisite: Bot. 421. Spring term, odd years. *Mr. Hillson*

BUSINESS ADMINISTRATION

Robert D. Pashek
In Charge of Graduate Programs in Business Administration
122 Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.
Graduate Faculty: Professors Bradley, Carzo, Cook, Day, Ferrara, Greenlaw, Kelley, Kniffin, McKinley, G. K. Nelson, Pashek, Richards, Saylor, Schrader, Strong, Waters, and Wherry; Associate Professors Babione, Clewett, Coyle, Hammond, Phalan, Sussman, and Williams; Assistant Professor Mock.

The M.B.A. program is designed for those desiring professional education in business administration, regardless of their undergraduate background, in preparation for a career in either business or teaching. An applicant with little or no training in business administration may be admitted to the M.B.A. program and may schedule necessary preparatory courses while pursuing the graduate program. Three credits are required as preparatory courses in each of the following: accounting, business law, business statistics, economics, finance, management, and marketing.

The M.S. and Ph.D. degrees with a major in business administration are designed for those interested primarily in research and teaching.

For admission to these programs, a minimum of 18 acceptable undergraduate credits in the fields of accounting, commerce, economics, and business statistics—

including at least 6 in economics and 3 in business statistics—is required. An applicant may be admitted with slight specific deficiencies which must be made up without degree credit.

Applicants for the various graduate programs in business administration are required to take the Admission Test for Graduate Study in Business given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. The test is given at University Park and at numerous locations in most states and foreign countries in November, February, April, and July. For dates and locations see the *Bulletin of Information,* Admission Test for Graduate Study in Business, published by the Educational Testing Service, Princeton, New Jersey. Applicants should read the bulletin carefully. All arrangements for taking the test must be made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Advanced Auditing (3-9)
404. Cost and Budgetary Control (3)
406. Advanced Federal Tax Accounting (3)
407. Contemporary Issues in Accounting (3)
409. Machine and Electronic Accounting Methods (3)

500. Accounting Seminar (3-6)

502. Managerial Accounting (3-6) Accounting techniques as control devices in business and industry; the use of quantitative data for policy decisions.

511. Interpretation of Account Data (3)

520. Problems in Accounting (3-6) Planned individual projects involving library, laboratory, or field work.

COMMERCE (COM)

406. Investment Valuation and Management (3)
408. Credit Institutions (3)
418. Estate Planning (3)
424. Marketing Research (3)
427. Retail Buying and Merchandising (3)
461. Regulation of Transport Carriers (3)
462. Problems in Trade and Transportation (3)
491. Urban Land Utilization (3)

503. Transportation and Public Utility Seminar (3-6)

504. Problems in Commerce (3-6) Planned individual projects involving library, laboratory, or field work.

517. International Business Practices (3) Practices of exporters and importers dealing in commodities traded in world markets under competition, monopoly, or governmental control. Prerequisite: Com. 162.

523. Seminar in Marketing (3-6) Research in modern marketing trends.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision-making.

534. Marketing Management (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

537. Risk Management (3) Analysis of managerial problems and responsibility for risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

538. Transportation and Physical Distribution (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

540. Business Administration Theory and Practice (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

552. Business Research Methods (3) Research methods applicable to business problems with emphasis on means of obtaining data and the logic underlying research design.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

567. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administration.

MANAGEMENT (MGMT)

430. Administrative Management (3)
435. Cases in Public Relations (3)

510. Operations Management (3) Integration and application of decision-making to operational and policy problems within the business firm.

520. Organization Theory (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

522. Personnel Management (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

530. Seminar in Management (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

BUSINESS EDUCATION

F. Wayne House
In Charge of Graduate Programs in Business Education
243 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

This program provides advanced preparation for teachers of business subjects for secondary schools and colleges. The subject-matter areas encompass secretarial, accounting, retailing, clerical, and general business sequences. The program may be adapted for the preparation of supervisors of business education.

A minimum of 18 acceptable undergraduate credits in education and psychology plus a minimum of 30 credits in business and business education subjects are required for admission.

All candidates specializing in business education are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanities.

BUSINESS EDUCATION (BUS ED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

511. Internship in Business Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CERAMIC TECHNOLOGY

Floyd A. Hummel, *Head of the Department*
214 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Buessem, Hummel, Weyl, and Williamson; Associate Professors Rindone and Stubican; Assistant Professor McKinstry.

The background for admission is a bachelor's degree in ceramics or in one of the related physical sciences. A knowledge of differential and integral calculus is required together with adequate physics and chemistry.

In view of the wide field covered by ceramic technology, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass technology. This makes it easily possible for students whose major subject for the bachelor's or master's degree has been either physics or chemistry to take appropriate graduate studies in ceramic technology.

Special facilities exist for research in the areas of clay mineralogy, phase equilibria, mineral synthesis, mechanical properties, ferrite and ferroelectric studies, glass technology, and high temperature reaction kinetics.

CERAMIC TECHNOLOGY (CER T)

400.	Crystal Chemistry of Ceramic Materials (2)	*Mr. Brindley*
402.	Principles of Ceramic Engineering (3)	*Mr. Williamson*
404.	Ceramic Seminar (1)	*Mr. Hummel*
405.	Ceramic Research and Design (1)	
406.	Rheology and Fluid Properties of Ceramic Systems (2)	*Mr. Williamson*
407.	Ceramic Materials Laboratory (2)	*Mr. Williamson*
408.	Heat Treatment of Ceramic Materials (1)	*Mr. Stubican*
409.	Heat Treatment Laboratory (2)	*Mr. Stubican*
410.	Phase Relations in Ceramic Systems (3)	*Mr. Hummel*
411.	Principles of Ceramic Processes (2)	*Mr. Buessem*
412.	Surface Chemistry of Ceramic Materials (1)	*Mr. Weyl*
414.	Principles of Ceramic Technology (2-3)	*Mr. Hummel*
415.	Principles of Glass Technology (3-4)	*Mr. Rindone*
420.	Refractories (2-3)	*Mr. Stubican*
425.	Ceramic Research and Design (2)	
430.	Electroceramics (2-3)	*Mr. Buessem*

500. Seminar in Ceramic Technology (1-2 per term) Current developments in ceramic technology and related fields. Required of all graduate students in ceramic technology. *Mr. Hummel and Staff*

501. Colloidal Behavior of Clays and Muds (2-4) Colloidal properties of ceramic clays, glazes, drilling muds, filtering and bleaching clays, and kindred systems. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Technology (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452.

506. Mechanical Properties of Ceramic Materials (2-3) Experimental stress-strain-time relations in elasticity, anelasticity, plasticity, and rupture; theory of strength and control. *Mr. Buessem*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Buessem*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. Chemical Aspects of the Constitution of Glass (1-3 per term) Historical development, properties, and atomistic interpretation of changes of properties with compositions, temperature, and past history. *Mr. Weyl*

512. Physical Aspects of the Constitution of Glass (1-3) Atomic structure of glass, its relation to physical properties; rheology; glass as a liquid. *Mr. Rindone*

515. Special Problems in Ceramic Technology (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Technology (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Bates*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in ceramic technology studies are listed under Mineral Sciences. The subject of color in glasses is treated in Min. 521.*

CHEMICAL ENGINEERING

Merrell R. Fenske, *Head of the Department*
131 Chemical Engineering Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Carnahan, Fenske, Jones, McCormick, and Quiggle; Associate Professors Braun, Hersh, and Klaus.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, unit operations, unit processes, nuclear chemical engineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. The facilities for instruction and research in chemical engineering and petroleum chemistry include those of the Petroleum Refining Laboratory.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit.

Thesis research for the M.S. and Ph.D. degrees in chemistry may be done in the Department of Chemical Engineering.

CHEMICAL ENGINEERING (CH E)

404. Chemical Plant Design (3) *Messrs. Engel and Snyder*
405. Thermodynamics for Chemical Engineers (3) *Mr. Snyder*
406. Chemical Engineering Problems (3) *Messrs. Engel and Snyder*
410. Chemical Engineering Principles (3) *Messrs. Carnahan and Kabel*
411. Chemical Engineering Principles (3) *Messrs. Carnahan and Kabel*
412. Chemical Engineering Principles (3) *Messrs. Carnahan and Kabel*
420. Cryogenic Engineering (3) *Mr. Fritz*
422. Petroleum Processes and Products (2) *Mr. Peiffer*
430. Nuclear Chemical Engineering (3)

435. Chemical Reaction Kinetics (3) *Mr. Kabel*
440. Chemical Engineering Materials (3) *Mr. Engel*
445. Chemical Engineering Research (1-5)
450. Process Dynamics (3) *Mr. Snyder*
460. Chemical Engineering (4) *Mr. Daubert*

500. Seminar in Chemical Engineering (1) Required of all graduate students.

505. Special Topics in Chemical Engineering (2-12) Intensive study in the various specialized fields of chemical engineering.

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Mass Transfer (3) Problem course on developments in diffusion, fluid dynamics, and phase equilibrium.

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

530. Heat Transfer in Nuclear Reactors (3) Fluid flow, heat transfer, and design problems in nuclear reactor systems.

535. Applied Reaction Kinetics (3) Basic principles of chemical kinetics, simultaneous heat and mass transfer, and prediction of rates; their application to reactor design.

CHEMISTRY

Thomas Wartik, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S., M.Ed.
Graduate Faculty: Professors Aston, Deno, Dixon, Fritz, Hutchison, Jordan, Miller, Noll, Oakwood, Quiggle, Seward, Skell, Smith, Sommer, Taft, Wartik, and Zook; Associate Professors Ascah, Bernheim, Goodman, Haas, Haim, Hayes, Hisatsune, Jones, Lampe, Richey, Schempf, Shamma, and Steele; Assistant Professors Adams, Gingerich, Lotz, Matwiyoff, Rosenblatt, and Schmulbach.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent and the computer, cryogenic, microscopy, petroleum, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at 1 p.m. at a departmental colloquium.

Students entering programs leading to the M.S. and Ph.D. degrees should have had training which includes at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is required, and a reading knowledge of at least one foreign language, preferably German, is expected.

The program leading to the M.Ed degree is designed primarily for science teachers in secondary schools. Previous training should include a total of 18 credits in chemistry and 18 credits in education and related psychology.

Prior to scheduling their first term program, new students will take examinations in the four areas of analytical, inorganic, organic, and physical chemistry. The infor-

mation obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. Chemical Literature (1)
401. Seminar (1)
405. Nuclear and Radiochemistry (3)
410. Advanced Inorganic Chemistry (4)
*421-422. Analytical Chemistry (4 each)
426. Instrumental Methods of Analysis (3-5)
435. Organic Preparations and Laboratory Methods (3-5)
437. Qualitative Organic Analysis (3)
448. Colloid Chemistry (3)
*451-452. Physical Chemistry (3 each)
453. Advanced Physical Chemistry (3)
454. Advanced Physical Chemistry (3)
455. Physical Chemistry of High Polymers (3)
*457-458. Experimental Physical Chemistry (1 each)
459. Experimental Physical Chemistry (1)
470. Chemical Microscopy (3)
471. Special Topics in Chemical Microscopy (2-6)
472. Quantitative Organic Microanalysis (3)
474. Quantitative Organic Microanalysis (3)
477. Chemical Photomicrography (3)
489. Introduction to Chemical Research (1-10)
†490. Organic Chemistry (5)
†491. Organic Chemistry (5)
†492. Advanced General Chemistry for Teachers (3)
†493. Selected Topics in Chemistry for Teachers (3)
†494. Chemical Demonstrations for Teachers (3)

500. Seminar in Inorganic Chemistry (1 per term)

501. Seminar in Physical Chemistry (1 per term)

502. Seminar in Organic Chemistry (1 per term)

503. Seminar in Analytical Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Separative and determinative processes in analytical chemistry.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12)

534. Theoretical Organic Chemistry (3) Modern theories of structure; resonance; interpretation of physical properties; theory of rates; equilibrium properties.

Mr. Aston

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.
†Candidates for the M.Ed. degree.

535-536. Organic Chemistry (3 each) Adapted to the needs of those doing research work in organic chemistry.

538. Organic Chemistry (3) Survey of organic chemistry arranged primarily for graduate students majoring in fields other than organic chemistry.

542. Colloids (3) The physics and chemistry of surfaces and their resulting colloid properties; methods of preparing colloids. *Mr. Smith*

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Chemical Thermodynamics and Introductory Statistical Mechanics (3) Continuation of Chem. 544 including the calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisite: Chem. 544.

546. Quantum Chemistry (3) Calculation of electronic properties of atoms and molecules by wave mechanical methods including molecular orbital theory. Prerequisite: Chem. 565.

547. Statistical Mechanics (3) Properties of matter at equilibrium, developed on the basis of energy levels of molecules and statistical mechanical theory. Prerequisite: Chem. 565.

560. Topics in Physical Chemistry (3-12)

561. Chemical Principles (3) Mathematical treatment of the classical principles of chemistry; their application to problems. Required of all graduate students. Prerequisites: Chem. 452, Math. 44, Phys. 204. A course in organic chemistry is recommended.

563. Chemical Kinetics (3) Theory and measurement of the rates of chemical reactions; the mechanism of chemical reactions.

564. Chemical Kinetics (3) Continuation of Chem. 563 including theory and measurement of photochemical reactions.

565. Atomic and Molecular Structure (3) Introduction to modern theoretical chemistry: chemical bonds and molecular spectra.

567. Advanced Theoretical Chemistry (3) Modern and current theories of the properties of chemical substances and their applications to chemical problems; the construction of chemical theory.

581. Experimental Methods in Petroleum Chemistry (1-12)

582. Topics in Petroleum Chemistry (2-6)

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS

Winona L. Morgan, *Head of the Department*
105E Home Economics South

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Britton, Harms, Morgan, and Smith; Associate Professors Broderick and de Lissovoy.

Students may specialize in the guidance and development of children, relationships among various members of the family, problems of all stages of the family cycle, nursery school education, education for home and family living in the schools, parental education, and work with children and families in community agencies.

The entering student should have had at least 6 credits in the physical and biological sciences, 12 in the social sciences (which must include a basic course in sociology and one in psychology), and 6 in child development and family relationships. Students who are otherwise qualified but who lack some of these credits may be admitted and permitted to make up the deficiency credits along with a graduate program.

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CD FR)

418. Family Relationships (3) *Mr. Broderick*
429. Advanced Child Development (3) *Mr. de Lissovoy*
430. Teaching in Nursery School (1-6) *Mrs. Hull*
441. Nursery School Organization (3) *Mrs. Hull*
445. (Psy. 445) Development Throughout Adulthood (3) *Mr. Britton*
481. Educational Methods with Preschool Children (3) *Mrs. Hull*

500. Nonthesis Research (1-6)

508. Parental Education (3) Discussion and use of methods, experiences, and programs which can be used effectively to help parents in dealing with problems of parent-child relationships. *Miss Morgan*

515. The Teaching of Child Development and Family Relationships (3) Methods of selection and presentation of subject matter basic to understanding the development of children. *Miss Morgan*

529. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 credits in child development or 6 in educational or child psychology, plus 3 in statistics. *Miss Harms*

530. Problems in Child Development and Family Relationships (1-6) Problems involving individual research in library, laboratory, or field projects.

536. (Psy. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

545. The Family in Its Community (3) Cultural influences on family relationships; how the family orients its members to community living and group participation. *Mr. Broderick*

546. Seminar in Family Relationships (1-6) Reading, reports, and discussion of recent research in relationship aspects of family living; particular attention to studies of roles, crises, and adjustments within the family setting. *Mr. Broderick*

548. Survey of Research on Sexual Behavior (3) Survey and evaluation of the contributions to the studies of sex by H. Ellis, Freud, Malinowski, Terman, Kinsey, and others. Prerequisites: 12 credits at the 400 and 500 level in child development and family relationships, psychology, sociology, or anthropology; 3 credits in statistics.

549. (Psy. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

CIVIL ENGINEERING

BENJAMIN A. WHISLER, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.
Graduate Faculty: Professors Kountz, Perez, Shulits, and Whisler; Associate Professors Barnoff, Blue, Gotolski, Larson, Nesbitt, and Underwood.

The entering student should be a graduate in civil engineering from an accredited college of engineering. Students may specialize in structures, hydraulics, transportation engineering, surveying, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.
See also "Sanitary Engineering."

CIVIL ENGINEERING (C E)

400. SEMINAR (1-3)
401. CIVIL ENGINEERING PROJECTS (2-12)
421. HIGHWAYS AND STREETS (3)
423. HIGHWAY SAFETY AND TRAFFIC CONTROL (3)
424. CIVIL ENGINEERING MATERIALS (3)
431. CIVIL ENGINEERING CONSTRUCTION (3)
446. ADVANCED SOIL MECHANICS (3)
447. ADVANCED STRUCTURAL ANALYSIS (3)
448. ADVANCED STRUCTURAL DESIGN (3)
462. OPEN CHANNEL HYDRAULICS (3)
465. RIVER AND WATERWAYS ENGINEERING (3)
471. ENVIRONMENTAL SANITATION (3)
472. WATER POLLUTION CONTROL (3)

500. SEMINAR IN CIVIL ENGINEERING (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

501. CIVIL ENGINEERING PROJECTS (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

521. TRANSPORT PLANNING AND DESIGN (2-6) Planning and design of transportation facilities; basic principles and engineering techniques applied to airways, highways, pipe lines, railways, waterways.

524. ADVANCED PROBLEMS IN CIVIL ENGINEERING MATERIALS (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

540. ADVANCED STRUCTURAL ANALYSIS (2-4) Geometry of flexure, deflections; analysis of continuous beams, rigid frames, arches; influence lines. Prerequisite: C.E. 46.

541. ADVANCED STRUCTURAL ANALYSIS (2-4) Truss deflection; trusses with redundant members, continuous trusses, framed arches; influence lines; secondary stresses; wind stresses; space framework; suspension bridges. Prerequisite: C.E. 46.

544. ADVANCED STRUCTURAL DESIGN (2-4) Plain and reinforced concrete design as applied to buildings, bridges, retaining walls, domes, tanks, and dams; prestressed concrete. Prerequisite: C.E. 448.

545. Advanced Structural Design (2-4) Structural steel design as applied to riveted and welded girders, trusses, rigid frames, wind connections; timber design. Prerequisite: C.E. 41.

547. Advanced Structural Theory (3-6) Prestressed concrete, arches, suspension bridges, concrete dams, thin shells, and other current topics. Prerequisite: C.E. 447.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fluids (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Advanced Problems in Sanitary Engineering (3-10) Investigations, analyses, and reports on current topics in sanitary engineering.

574. Analytical Evaluations in Sanitary Engineering (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Sewage Treatment Plant Design (1-6) Design of works for treatment of sewage or industrial wastes. Prerequisite: C.E. 71.

578. Industrial Hygiene (3) Principles of control of industrial toxics and the protection of the worker and the community.

CLOTHING AND TEXTILES

Ruth W. Ayres, *Head of the Department*
120A Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professor Ayres; Associate Professors Densmore, Gates, and Tesi.

Work may be taken with major emphasis in the textile area, which stresses the background natural sciences, or in the clothing area, which stresses the background social sciences. Candidates are accepted who have a strong foundation and a good record in any of the following: home economics, chemistry, sociology, economics, or psychology.

CLOTHING AND TEXTILES (CL TX)

400. Special Problems in Clothing and Textiles (1-6)
402. Fundamental Principles of Tailoring Construction (3) *Mrs. Larson*
403. Creative Pattern Making (3) *Mrs. Larson*
404. Draping (3) *Mrs. Larson*
406. Fashion Promotion (3) *Mr. Tesi*
407. The Textile and Clothing Industry (3) *Mr. Tesi*
408. Intermediate Textiles (3) *Miss Densmore*
410. Clothing for the Family (3) *Mrs. Adams*
411. Advanced Clothing Construction (3) *Mrs. Larson*

500. Nonthesis Research (1-6)

501. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

506. Clothing Behavior (3) Analysis and interpretation of clothing behavior through the application of theories selected from the behavioral sciences. *Miss Gates*

507. Problems in Relation to Clothing Consumption (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries. *Mr. Tesi*

508. Special Problems in Clothing and Textiles (1-6) Individual directed study, investigation, and practice in selected phases of textiles and clothing.

509. Seminar in Clothing and Textiles (1-6)

510. Research Methods and Evaluation in Clothing and Textiles (1-6) *Misses Densmore and Gates*

511. Current Developments in Clothing and Textiles (1-6) *Miss Ayres*

512. History of Clothing and Clothing Construction (3) *Miss Gates*

513. Advanced Textile Technology (6) *Miss Densmore*

COMPARATIVE LITERATURE

Philip A. Shelley
Chairman of the Committee on Comparative Literature
229 Sparks Building

Degrees Conferred: Ph.D., M.A.

Programs are arranged through a meaningful selection of courses offered by the several departments of languages and literatures, both ancient and modern, as well as of those specifically in the category of comparative literature. More than a minimum knowledge of foreign languages is required.

A thesis is required of all M.A. candidates in this major.

COMPARATIVE LITERATURE (C LIT)

400. Comparative Method in Literary Studies (3) *Miss Lüders*
443. (Ger. 443) Literary Relations of Germany with England and America (3-9) *Mr. Shelley*

470. Old Masters of the Modern Novel (3) *Mr. Morse*
480. Introduction to Folklore (3) *Mr. Bayard*

500. Seminar in Comparative Literature (3-6)

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to backgrounds, development, themes, and characteristics. *Mr. Bayard*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. Morse*

COUNSELOR EDUCATION

George R. Hudson
In Charge of Graduate Programs in Counselor Education
114 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professor Wellington; Associate Professors Hudson and Hylbert.

Professional preparation programs are offered at the master's level for school counselors (elementary or secondary), college student personnel workers, and rehabilitation counselors. Doctoral programs prepare for pupil personnel administration, college student personnel administration, or supervision of rehabilitation.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits in economics, education, psychology, sociology, and physiology or anatomy with some credits in at least three of these areas.

Because school counselors need two years' experience as teachers, social workers, or professional counselors in order to be certified, the experience requirement must be met before receiving a degree. Prospective school counselors lacking such experience should plan to work for their degrees over a series of summers while acquiring requisite experience through the remainder of the year. Those wishing to become college student personnel workers must have a year of appropriate work experience in a college setting before receiving a degree. Prospective rehabilitation counselors are provided with an off-campus supervised internship as part of their professional preparation.

All Counselor Education degrees at Penn State are based, in addition to Graduate School requirements, on demonstrated counselor competencies.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

Courses in counselor education are listed under the offerings of the Department of Educational Services (see page 96). Additional courses are selected from other areas and departments.

DAIRY SCIENCE

Donald V. Josephson, *Head of the Department*
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Almquist, Josephson, Kesler, Patton, and Watrous; Associate Professors Flipse and Keeney; Assistant Professor McCarthy.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipide metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, zoology, or agricultural economics.

Prerequisite to graduate work is the completion of an undergraduate major in dairy science or a related science area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

DAIRY SCIENCE (D SC)

418. Dairy Survey (1) *Mr. Josephson*
421. Technical Control Problems (1-10) *Messrs. Watrous and Keeney*
427. Milk Secretion (3) *Mr. Kesler*
428. Dairy Production Problems (1-6) *Mr. Kesler and Staff*
431. Physiology of Reproduction in Farm Animals (3) *Mr. Almquist*

501. Butter and Cheese (1-6) Manufacture and handling of butter and cheese. Prerequisites: D.Sc. 10, 23, Bioch. 404, Micrb. 8. *Mr. Watrous*

502. Condensed Milk and Milk Powder (1-6) Condensing and drying of milk. Prerequisites: D.Sc. 10, 26, Bioch. 404, Micrb. 8. *Mr. Keeney*

503. Public Milk Problems (1-6) Handling milk in modern plants. Prerequisites: D.Sc. 11, Bioch. 404, Micrb. 8. *Mr. Watrous*

504. Ice Cream Manufacture (1-6) Manufacture of ice cream, ices, and other frozen milk products. Prerequisites: D.Sc. 11, Bioch. 404, Micrb. 8. *Mr. Keeney*

505. Dairy Plant Economics (1-6) Economic factors involved in creamery operation and management. Prerequisites: D.Sc. 7, 11. *Mr. Watrous*

507. Dairy Cattle Management (1-6) Management of dairy cattle. Prerequisite: D.Sc. 27. *Mr. Kesler and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

509. Testing Dairy Products (1-6) Constituents of dairy products. Prerequisites: D.Sc. 11, Bioch. 404, Micrb. 8.

510. Dairy Cattle Feeding (1-6) Application of fundamental research in animal nutrition to the feeding of dairy cattle. Prerequisites: D.Sc. 1, 29. *Mr. Kesler*

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Zool. 422, 3 credits in statistics.

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Mr. Josephson and Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. Flipse*

522. Research Procedures in Dairy Technology (3) Research problems and methods in dairy technology with major emphasis on dairy chemistry. Prerequisite: Bioch. 404. *Mr. Patton*

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

EARTH SCIENCES

Hans Neuberger
Chairman of the Committee on Earth Sciences
323 Mineral Industries Building

Degree Conferred: M.Ed.

This program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, meteorology, mineralogy, and soils.

The program prepares candidates to teach at least one field of the earth sciences, familiarizes them with at least two additional earth science subjects, and at the same time enables them to increase their competence in the physical sciences, the biological sciences, and mathematics.

The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

ECONOMICS

Grant N. Farr, *Head of the Department*
326 Boucke Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Professors Budd, Farr, Kaufman, Mares, Mason, Newman, Reede, Rozen, Saylor, and Stout; Associate Professors Iwand, Klein, Myers, Prybyla, Robinson, and Sauerlender.

Opportunities are available for concentration in the following fields: economic theory and doctrines, labor economics, public finance, international economics, market organization and control, money, banking and business cycles, economic growth, comparative economic systems, Soviet-type economics, mathematical economics and econometrics, and business statistics.

A thesis is required of all M.A. candidates in this major.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics.

BUSINESS STATISTICS (B S)

403. Intermediate Business Statistics (3)

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)
404. Current Economic Issues (3)
405. Advanced Economic Analysis (3)
412. Economics of Collective Bargaining (3)
415. Social Insurance (3)
418. Economics of Wages and Employment (3)
419. Case Studies in Labor-Management Relations (3)
423. State and Local Taxation (3)
429. Advanced Public Finance (3)
433. International Monetary Economics (3)
442. Monopoly, Competition, and Their Regulation (3)
450. The Business Cycle (3)
451. Advanced Money, Banking, and Fiscal Policy (3)
452. The Money Markets (3)
461. Economic Growth: Underdeveloped Areas (3)
462. Economic Growth: Theories of United States Development (3)
480. Mathematical Economics (3)
490. Measurement of the Economy (3)
491. Analysis of Linear Economic Models (3)
499. Foreign Study in Economics (2-6)

500. Economics Seminar (3-6)

506. Problems in Economics (3-6) Planned individual projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulations of the quantity theory; liquidity approach to monetary theory; current issues in monetary theory and policy.

510. Econometrics (3) Statistical estimation in mathematically formulated economic relationships.

512. Wage Determination (3) Development of wage and employment theory; structure of labor markets; impact of unions on income distribution, price level, and employment.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

529. Public Finance (3) Contemporary problems in public finance; instruments of fiscal policy in the achievent of full employment, price stability, and economic development.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision-making and control.

572. Soviet and Other Centrally Planned Economies (3) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

EDUCATIONAL ADMINISTRATION

Walter J. DeLacy
In Charge of Graduate Programs in Educational Administration
303 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Davison, DeLacy, McAulay, McGarey, Miller, and Remaley; Associate Professors Bosch and Willower.

Professional preparation programs are offered at the master's level for elementary and secondary school principals and supervisors. Doctoral programs prepare for positions of supervising principal, assistant superintendent, and superintendent of schools.

Requirements for admission to a graduate program in educational administration include 18 approved undergraduate credits in education and psychology. Applicants

for admission to the master's degree program are required to have had one year of teaching experience, or to be currently engaged in teaching. Two years of teaching experience are required for admission to the doctoral program.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600 or 610 thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term, unless approved by the candidate's committee, shall be considered automatic withdrawal.

Although candidates are required to specialize in a field of professional education, they are also encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

Courses in educational administration (Ed.Ser. 480 and 565 to 582 inclusive) are listed under the offerings of the Department of Educational Services. Additional courses may be selected from other areas and departments to meet the student's needs, including certification requirements.

DEPARTMENT OF EDUCATIONAL SERVICES—This department (Franklin A. Miller, *Head,* 204 Education and Psychology Center, Building II) offers graduate programs in counselor education, educational administration, and higher education. It also offers the following course sequences which are not graduate majors:

Adult Education	460, 575
History and Philosophy of Education	415-420, 516-523
Research, Seminars, and Projects	596-599
Safety Education	450-452
Special Education	425-431, 525-529

These courses carry graduate credit and, with the approval of the student's adviser, may be applied toward the requirements for an advanced degree in any major field.

EDUCATIONAL SERVICES (ED SER)

403. Guidance Principles and Practices (3)
404. Teaching and Group Guidance About Occupations (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
415. Character Education (2-3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
420. History of Modern European Education (3)
425. Education of Exceptional Children (2-3)
427. Education of the Mentally Retarded (2-3)
429. Education of the Mentally Gifted Child (1-3)
430. Practicum in the Education of Atypical Children (1-8)
431. Atypical Children and Educational Adjustments (3)
450. Visual and Other Aids in Safety Education (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisites: Ed.Ser. 506, Ed.Psy. 451.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals.

505. Occupational and Educational Information (3) Occupational information for guidance purposes; educational information related to vocational choice and preparation. Prerequisite: Ed.Ser. 403.

506. Student Analysis Procedures for Counselors (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing.

507. Supervised Experience in Student Counseling (3) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Ed.Ser. 403.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Ed.Ser. 403.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Ed.Ser. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Ed.Ser. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisite: Ed.Ser. 511.

513. Supervision of Guidance Workers (3) Practical experience in supervising and evaluating work of counselors. Prerequisite: Ed.Ser. 507.

516. Social Foundations of Education (2-4) Social institutions and functions and their relationship to public education; analysis of the functions assignable to formal education. Prerequisites: El.Ed. 311 or Sec.Ed. 331; Ed.Psy. 14.

517. Advanced Philosophy of Education (2-4) Analysis of educational policy and practice for philosophic consistency and commitment; philosophical implication in selected educational literature.

518. Evolution of Educational Thought (2-3) Rise of formal educational philosophy from Plato to John Dewey; preliminary reference to Chinese, Hindu, Chaldean, Persian, Hebrew, and Egyptian theories.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina.

522. Comparative European Education (3) Educational policies and practices in school systems in western and central European nations. Prerequisite: Ed.Psy. 14.

523. Education in Russia, Asia, and the Middle East (2-3) Current educational activities in Soviet Russia and other eastern European countries; the Middle East, North Africa, and the Far East.

525. Internship in Special Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

527. Problems in the Education of the Mentally Retarded (1-4) Study of exist-

ing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience; Ed.Ser. 425 or 577, and Ed.Ser. 427.

529. Problems in the Education of the Mentally Gifted (1-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience; Ed.Ser. 425 or 577, and Ed.Ser. 429.

545. Higher Education in the United States (2-3) Historical perspective and current status; development of functions and structures; issues in curriculum, admissions, government, administration, and finance.

546. The Principles of College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in College Teaching (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professional Education of Teachers (3) Development and present status of teacher education; objectives and standards; selection and guidance of students; personnel problems in relation to staff. Prerequisite: 6 credits in advanced courses in education and a course in educational psychology.

551. Student Personnel Programs at the College Level (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

555. Seminar in Collegiate Education (1-6) Special topics in higher education. Prerequisite: courses or experience in higher education.

565. Principles of School Supervision (2-3) Organization of supervision; planning the supervisory program; developing standards of teaching and learning; improvement of learning through tests and teacher rating. Prerequisites: 18 credits in education and 3 years' teaching experience.

566. The Elementary School Principal as Supervisor (2-3)

567. The Secondary School Principal as Supervisor (2-3) Improvement of instruction; improvement of teachers in service; evaluation of teaching procedures; methods of supervision; selection and use of textbooks. Prerequisite: three years' teaching experience.

568. The Elementary School Principal as Administrator (2-3) Duties of the elementary school principal in organizing and administering his school.

569. The Secondary School Principal as Administrator (2-4) Problems of schedule making, teachers' meetings, curriculum making and revision, organization of extra-curricular and guidance programs. Prerequisite: teaching experience.

570. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) Utilization of public participation in the formulation of school policies; relation of the school staff to the public and techniques for informing the public about what schools can do. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

574. State and National Education Programs (2-3) Existing state and federal functions and relations to education; proposed programs. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes; torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

577. The Administration of Public School Education for Atypical Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Factors which make for the improvement of public schools; influences with which administrators may work to improve the schools in their local situations; subjection of data on individual administrative situations to scientific check. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience; Ed.Ser. 573.

580. Seminar in School Administration (1-6) Efficiency in supervision, methods of diagnosis and evaluation of teaching and learning procedure, improving instruction, maintaining teacher morale, stimulating cooperative work. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

581. Educational Survey Techniques (2-3) Methods for appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

596. Seminar in Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Education (1-6) Independent work in the study of topics in education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

599. Internship in Public School Research (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

EDUCATIONAL PSYCHOLOGY

William Rabinowitz, *Head of the Department*
311 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors DiVesta, Mitzel, Rabinowitz, Torkelson, and Van-Ormer; Associate Professors Lathrop and Thevaos; Assistant Professors Snyder and Wodtke; Mr. Greenhill.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems, including programmed learning. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Special facilities include a research design laboratory, a laboratory for computer-based instruction, a self-instruction media laboratory, facilities for film production and editing, and a closed-circuit television studio in Chambers Building used for both research and instruction. Facilities in other departments available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with an IBM 7074 Computer, is available for use in graduate student research.

Requirements for admission include a broad undergraduate background including some college mathematics, a minimum junior-senior scholastic average of B, and a satisfactory scholastic aptitude rating on either the Graduate Record Examination or the Miller Analogies Test. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one third of their graduate credits of "A" quality.

Doctoral degree requirements include a major emphasis in one of the above areas

of educational psychology with minor emphasis in two related areas (one being in this department). Typically, the doctoral program of study would include at least one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, instructional media, measurement, social or industrial psychology, clinical psychology, experimental psychology, and developmental psychology.

EDUCATIONAL PSYCHOLOGY (ED PSY)

400. Statistical Interpretation of Educational Research (2)
406. Applied Parametric and Nonparametric Statistics in Education (3)
407. Regression and Correlation Methods for Educational Data (2)
421. Learning Theories Applied to Educational Practice (3)
435. Orientation to Instructional Media (2)
436. Production and Utilization of Graphic Stimulus Materials (3)
437. Production of Educational Motion Pictures (3)
443. Television in Education (3)
450. Principles of Measurement (3)
451. Appraisal and Interpretation of Standardized Group Tests (2)
475. Introduction to Educational Research (2)

506. Advanced Techniques for Analyzing Educational Experiments (2) Advanced techniques for research in education; analysis of covariance; repeated measures; randomized block designs; Latin square; and other experimental arrangements. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

520. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 421.

521. Concept-formation, Problem-solving, and Decision-making Processes in Schools (2) Study of paradigms and models of concept formation, problem-solving strategies, choice-making, and judgment as related to complex verbal learning. Prerequisite: Ed.Psy. 520.

530. Theory and Research in Programmed Learning (3) Research and trends in programmed learning; preparation of short programmed sequences for experimental analysis. Prerequisites: Ed.Psy. 450 and 421, or Psy. 404.

531. Organization and Administration of Media in Schools (2) Problems of providing instructional media in schools; the role of the media curriculum consultant in curriculum construction. Prerequisite: Ed.Psy. 435.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 15.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

558. Scaling Educational and Psychological Measures (2) Unidimensional and multidimensional scaling models with emphasis on psychometric methods and brief attention to psychophysical methods. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

599. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING

Arthur H. Waynick, *Head of the Department*
105 Electrical Engineering Building

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus)
Graduate Faculty: Professors Hagen, Holt, Mentzer, Ross, Volz, and Waynick; Associate Professors Atwater, Ferraro, Marsh, Nisbet, Pearson, and Schmerling; Assistant Professors Adams, El-Kareh, Hale, and Lee.

Course offerings and research facilities are available in the following areas: information theory, microwave theory and techniques, networks, computers (including digital, analog, and network analyzer), control, power conversion, servomechanisms, tubes and transistors, dynamical machine analysis, power dispatching, relay protection, and wave propagation.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate course work in electrical circuits, machinery, and electronics.

ELECTRICAL ENGINEERING (E E)

421a,b,c,d. Electrical Engineering Problems (2-12)
425. Symmetrical Components (3)
426. Transistors (3)
428. Servomechanisms (3)
432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
438. Electromagnetic Theory and Radiating Systems (3)
439. Pulse Techniques (3)
441. Active Circuits (3)
450. Electrical Network Theory (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Digital Computers (3)

514. Quantum and Solid State Electrical Engineering (3) Electron theory of atoms and solid structures, as applied to electrical engineering concepts and devices. Prerequisite: Phys. 412.

520. Seminar (1) Required of all graduate students in electrical engineering. Conferences, reading, and presentation of technical papers.

521. Advanced Electrical Engineering Problems (2-12)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

526. Transistors and Active Circuits (3) Advanced semiconductor electronic theory, transistor circuit analysis, and applications. Prerequisite: E.E. 426.

528. Servomechanisms (3) Advanced treatment of transient and steady-state behavior of closed-cycle control systems with special attention to stability and design of stabilizing controllers. Prerequisite: E.E. 428.

532. Ultra-High-Frequency Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisite: E.E. 432 or 438.

535. Engineering Analysis (3) Engineering applications of complex variables, conformal mapping methods, and potential plotting; Laplace transform methods and stability criteria. Prerequisite: E.E. 435.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electrical and magnetic fields, using the Maxwell-Lorentz equations as applied to vector fields and special solutions for antennae, wave guides, and other engineering applications. Prerequisite: E.E. 438.

550. Passive Network Synthesis (3) Network synthesis using (a) realizability conditions; (b) image parameters, realization methods for two-terminal pair networks; rational fraction approximations; time domain synthesis. Prerequisite: E.E. 450.

560. Information Theory (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; optimum filtering and prediction. Prerequisite: E.E. 45.

561. Information Theory (3) Mathematical measurement of information: information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 560.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 43 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

582. Radio Astronomy (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. Radio Astronomy (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: E.E. 582.

ELEMENTARY EDUCATION

A. Madison Brewer, *Head of the Department*
150 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Bixby, Brewer, McAulay, and Russell; Associate Professors Alessandro, Alfke, Bosch, Corle, Coulter, Veatch, and Zafforoni; Assistant Professor Riedesel.

The graduate programs provide advanced professional preparation for kindergarten teachers, elementary school teachers, and curriculum specialists. For admission 18 credits in elementary education, including teaching experience, are required.

ELEMENTARY EDUCATION (EL ED)

401. Training in Nature for Camp Counselors (3)
426. Problems of Elementary School Arithmetic (2-3)
433. Teaching Social Studies in the Elementary Grades (2-3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (2-3)
444. Reading Disabilities (2-3)
445. (Sec.Ed. 445) Techniques in Remedial Reading (2-6)
449. Teaching Children's Literature (2-3)
453. Special Problems in the Teaching of Elementary School English (2-3)
461. Elementary Education (2-3)
467. Advanced Theory of Kindergarten (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

546. (Sec.Ed. 546) Seminar on Reading Instruction (3-6) Research, procedures, and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: El.Ed. 443 or Sec.Ed. 443.

556. (Sec.Ed. 556) Reading Clinic Practice: Analysis of Reading Disabilities (3-6) Analysis of extreme reading disabilities and recommended remedial procedures; experience in preparation of case reports. Prerequisites: El.Ed. 444, El.Ed. (Sec.Ed.) 445.

557. Reading Clinic Practice: Remedial Procedures (1-9) Practicum in special classes for reading disabilities; corrective and remedial procedures; specific procedures for correction of various types of reading disabilities. Prerequisite: El. Ed. 444 or El.Ed. (Sec.Ed.) 556.

559. Reading Clinic Research (1-15) Prerequisites: El.Ed. 443 or Sec.Ed. 443; El.Ed. 444.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisite: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principals underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers, administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

594. Seminar in Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

ENGINEERING MECHANICS

Joseph Marin, *Head of the Department*
105 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.
Graduate Faculty: Professors Davids, Hardenbergh, Hu, Marin, Theocaris, Vierck, and Wislicenus; Associate Professors Inman, Jaunzemis, Neubert, and Sharma; Assistant Professor Weitsman.

Graduate study is available in the following areas: (1) mechanics of rigid bodies including dynamics, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration; (5) fluid mechanics.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics.

ENGINEERING MECHANICS (E MCH)

400.	Advanced Strength of Materials (3)	*Messrs. Kiusalaas and Marin*
401.	Elements of Vibrations (3)	*Messrs. Vierck and Neubert*
402.	Applied and Experimental Stress Analysis (3)	*Mr. Hill*
403.	Mechanics of the Solid State (4)	*Mr. Hu*
404.	Research in Engineering Mechanics (1-6)	
407.	Numerical Methods of Analysis (3)	*Mr. Sharma*
408.	Elasticity and Engineering Applications (3)	*Mr. Weitsman*
409.	Advanced Mechanics (3)	*Mr. Hardenbergh*
410.	Mechanics of Space Flight (3)	*Mr. Hardenbergh*
412.	Experimental Methods in Vibrations (3)	*Mr. Neubert*
413.	Plastic Analysis of Structures (3)	*Mr. Hu*
414.	Elements of Material Science (3)	*Mr. Inman*
421.	Continuum Mechanics (3)	*Mr. Jaunzemis*
422.	Continuum Mechanics (3)	*Mr. Jaunzemis*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13. *Mr. Marin*

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Mr. Theocaris*

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13. *Messrs. Hu and Weitsman*

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to internal pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics.

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potentials; applications. Prerequisite: E.Mch. 540. *Messrs. Jaunzemis and Weitsman*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 44 or 431. *Messrs. Davids and Jaunzemis*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 44 or 431.
Messrs. Vierck and Neubert

523. Relaxation Methods (3) Relaxation methods compared to iteration and other numerical methods of analysis; application to elasticity, plasticity, stability, fluid flow, heat transfer, and related fields. Prerequisites: E.Mch. 13 or 111, Math. 44. *Messrs. Vierck and Sharma*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: Math. 451 or E.E. 435 or M.E. 452. *Mr. Davids*

Unit A (3) Basic concepts of tensors; matrices; numerical procedures; approximation; Fourier, Legendre, and other orthogonal series; applications; Bessel and other special functions.

Unit B (3) Basic solutions of Laplace, diffusion, wave equations; boundary-value problems; Fourier, Laplace transforms; contour integration techniques; Caignard's, energy methods.

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical applications. Prerequisite: E.Mch. 522. *Mr. Neubert*

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14. *Mr. Marin*

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507.
Mr. Theocaris

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics.
Mr. Jaunzemis

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540 or 421.

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507.

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

ENGINEERING SCIENCE

Benjamin A. Whisler
Chairman of the Committee on Engineering Science
212 Sackett Building

Degree Conferred: M.Eng.

Programs leading to the degree of Master of Engineering with a major in engineering science are offered only at University Graduate Centers away from the main campus. The first such center was opened at King of Prussia in 1963. Others are in various stages of planning. Details of the programs available in the various Centers may be obtained by writing directly to the persons in charge. See the inside front cover for the addresses.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits of course work is required, of which at least 12 must be at the 500 level. A scholarly written report is also required.

A bachelor's degree in engineering or a closely allied field is required for admission.

ENGLISH

Henry W. Sams, *Head of the Department*
245 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Professors Bayard, Brady, Condee, Cramer, Davis, Euwema, Frank, Goldberg, Lewis, Major, Morse, Peck, Rubin, Sams, G. Smith, Sutherland, West, and Young; Associate Professors Austin, Bressler, Jewkes, Meserole, Oldsey, Reed, and Weintraub; Assistant Professors Borklund and Hansen.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work.

A thesis is required of all M.A. candidates in this major.

ENGLISH (ENGL)

408. Advanced College Grammar (3) *Miss McElwee*
411. Problems of Style (3)
412. The Writing of Fiction (3-6) *Messrs. Rubinstein and Barth*
413. Verse Writing (3-6)
414. Biographical Writing (3) *Mr. Weintraub*
422. Masters of British Literature (3-6)
423. History of British Literature (3) *Messrs. Major and Steese*
432. Masters of American Literature (3-6) *Messrs. Bressler, Davis, and Staff*
433. History of American Literature (3) *Messrs. Sutherland and Gidez*
434. Movements in American Literature (3-6) *Messrs. Hansen, Meserole, and Staff*
437. American Poetry (3) *Messrs. Rubin and Hansen*
438. American Drama (3) *Mr. Wellwarth*
445. Chaucer (3) *Mr. Frank*
447. British Poetry from Skelton to Dryden (3) *Messrs. Reed and Smith*
448. English Drama Before Shakespeare (3) *Mr. Jewkes*
449. Shakespeare: the Chronicle and Problem Plays (3) *Messrs. Reed and Smith*
451. Prose and Poetry of 18th Century England (3) *Mr. Sams*
455. The Novel in England to Charles Dickens (3) *Mr. Brady*
458. The Drama from Dryden to Sheridan (3) *Mr. Rogers*
461. British Prose of the 19th Century (3) *Mr. Cramer and Miss Austin*
462. Wordsworth and Coleridge (3) *Mr. Cramer and Miss Austin*
463. Byron, Shelley and Keats (3) *Mr. Peck*
465. Victorian Novel (3) *Miss Austin*
466. The American Novel to 1900 (3) *Messrs. Young and Oldsey*
467. Victorian Poetry (3) *Mr. Cramer*
470. Literature of the British Commonwealth (3) *Mr. Sutherland*
475. Modern British Fiction (3) *Messrs. Sutherland and Weintraub*
476. The American Novel Since 1900 (3) *Messrs. Young, Lewis, and Oldsey*
477. British and American Poetry of the 20th Century (3)
478. British and Irish Drama Since 1890 (3) *Mr. Weintraub*
481. History of English Literary Criticism (3) *Messrs. Sams, Bressler, and Borklund*
488. Modern Continental Drama (3) *Messrs. Weintraub and Wellwarth*
490. Rhetorical Theory and Practice (3) *Mr. Bowman*
491. Literature for Teachers in Secondary Schools (3) *Mr. Bressler*

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Messrs. Smith and Meserole*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. *Mr. Jewkes*

522. Old English Literature (3) A reading of the more important poetic works in Old English. *Mr. Jewkes*

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Messrs. Peck and Cramer*

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Messrs. Peck and Cramer*

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Cramer*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the 19th and 20th centuries. *Mr. Davis*

540. Studies in Elizabethan Prose and Poetry (3-6) *Messrs. Reed and Smith*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Mr. Frank*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer. *Mr. Frank*

543. Studies in Early 17th Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700. *Mr. Brady*

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Mr. Frank*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Messrs. Reed and G. Smith*

552. Swift and Pope (3) *Messrs. Sams and Brady*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Brady*

554. Studies in Early American Literature (3) *Messrs. Meserole and Hansen*

555. The Puritans (3) Critical studies of the principal works of English and American Puritans. *Messrs. Meserole and Hansen*

556. Eighteenth Century British Fiction (3) *Mr. Peck*

557. Early 18th Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. American Romanticism (3) The Romantic movement in American literature of the mid-19th century. *Messrs. Rubin, Davis, and Bressler*

561. Studies in the Romantic Movement (3-6) *Messrs. Peck and Cramer*

562. Studies in the Literature of Victorian England (3-6) *Mr. Cramer and Miss Austin*

564. Studies in 19th Century American Literature (3) The major figures treated will vary from year to year. *Messrs. Rubin, Davis, and Oldsey*

573. Studies in 20th Century British Literature (3-6) Major writers and literary movements. *Messrs. Morse and Weintraub*

574. Studies in 20th Century American Literature (3-6) Major writers and literary movements. *Messrs. Young and Lewis*

575. James Joyce (3-6) Alternate terms: *Ulysses* and *Finnegans Wake*. Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed. *Mr. Morse*

576. Hemingway and Faulkner (3) The major works. *Mr. Young*

578. Shaw (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. Eliot (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Mr. Lewis*

581. Contemporary Literary Criticism (3) *Messrs. Sams and Brady*

582. Hawthorne and Melville (3) Detailed study of the major works of both authors and of the relationship between the two men. *Mr. Young*

583. Emerson and Thoreau (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Bressler*

584. Whitman and Dickinson (3) The major texts, with special emphasis on background and language. *Messrs. Rubin and Davis*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature. *Mr. Lewis*

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserole*

590. Research Problems in British Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

591. Research Problems in American Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early 16th century to the present. *Mr. Bayard*

595. Studies in British Fiction (3-6) *Messrs. Sutherland and Weintraub*

596. Studies in American Fiction (3-6) *Messrs. Lewis and Young*

597. Studies in American Poetry (3-6) *Messrs. Rubin, Davis, and Hansen*

598. Readings in English (1-6) Programs of readings in English and American literature, designed to meet specific needs of individual students.

ENTOMOLOGY

Beckford F. Coon
Acting Head of the Department
317 Frear Laboratory

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Anderson, Cheng, Coon, and Frear; Associate Professors Boyle, Rutschky, and Smyth; Assistant Professor Snetsinger.

A student majoring in entomology may specialize in apiculture, ecology, economic entomology, forest entomology, morphology, physiology, insect resistances of plants, taxonomy, or toxicology of insecticides.

For admission a student is required to have 24 credits in entomology or zoology and related biological sciences; and he should have had chemistry through organic chemistry. Courses in physics and mathematics are also advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3)
402. Insect Ecology (3)
403. (Zool. 403) Systematics (3) *Mr. Boyle*
405. Insect Morphology (3) *Mr. Rutschky*
411. Insect Physiology (3) *Mr. Smyth*
413. Entomology Seminar (1 per term)
429. Insect Control (3) *Mr. Snetsinger*
431. Special Problems (1-6)
435. Arachnology (3)

506. Immature Insects (3) The morphology and taxonomy of the immature stages of insects. Spring term, even years.

520. Special Topics (1-6)

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years. *Mr. Smyth*

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications. *Mr. Smyth*

533. Physiology of Nerves, Muscles, and Sense Organs (2-6) Lectures and seminars on current literature on the function of excitable tissues of insects and other animals. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology. *Mr. Smyth*

540. Insect Resistance in Plants (2) Mechanism, expression, permanence, and measurement of resistance to insects with special reference to farm crops. Spring term, odd years. *Mr. Coon*

EXTENSION EDUCATION

Emory J. Brown
Chairman of the Committee on Extension Education
205 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competencies which enable them to become more effective professional workers. Options have been developed for the Colleges of Agriculture and Home Economics. Additional options will be offered as they are developed by other Colleges.

Entrance requirements for an M.Ed. in this major include a minimum of 18 credits in education and 12 in the social sciences and a strong background in agriculture or home economics. Entrance requirements for the M.Agr. degree include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

FAMILY ECONOMICS AND HOME MANAGEMENT

MARJORIE M. KNOLL
Head of the Department of Home Management, Housing, and Home Art
271 Home Economics South

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Harms, Hotchkiss, and Knoll; Associate Professor Smith.

Those interested in emphasizing a study of home management, family economics, family housing, and home equipment may do so through this major. There are no specific course requirements for admission.

In the graduate program family management practices, their effects upon members of the family unit, and the interaction of such practices with the local and national economy are studied in relation to principles of economics, philosophy, psychology, sociology, and political science.

CONSUMER SERVICE AND EQUIPMENT (CS EQ)

403. LECTURE-DEMONSTRATION TECHNIQUES (3)
413. HOME EQUIPMENT (3)
450. PROBLEMS IN HOUSEHOLD EQUIPMENT (1-6)

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

415. HOUSEHOLD BUYING PRACTICES (3)
419. MANAGING FAMILY FINANCIAL RESOURCES (3)
424. ECONOMIC CONDITIONS IN RELATION TO THE FAMILY (3)
439. MANAGEMENT PRINCIPLES IN HOME OPERATION (2)
442. RESIDENT EXPERIENCE IN HOME MANAGEMENT (3) Room and board will be charged at regular rates. *Miss Chennault*
445. HOME MANAGEMENT EXPERIENCE (3) *Miss Chennault*
477. FAMILY MANAGEMENT (3)

515. CONSUMER PROBLEMS (2-3) Methods of securing, evaluating, and presenting data concerning household commodities. For home economics teachers in high schools, colleges, and adult classes. Prerequisites: F.E.H.M. 442, F.N. 220.

524. ECONOMIC PROBLEMS OF THE HOUSEHOLD (3) Economic problems of the present-day family; special emphasis on factors in household production, use of money income, and standards of living. Prerequisites: Econ. 14, F.E.H.M. 439.

528. HOME MANAGEMENT SUPERVISION (2-3) Evaluation of objectives and techniques in organization, supervision, and teaching of the home management house experience. Prerequisite: F.E.H.M. 439.

543. HOME MANAGEMENT IN RELATION TO FAMILY LIVING (3) Includes work with families in solution of their management problems. Prerequisites: F.E.H.M. 439, F.N. 220.

544. PROBLEMS IN FAMILY ECONOMICS AND HOME MANAGEMENT (1-6) Investi-

gation of selected problems in family economics and home management. Prerequisite: 6 credits of family economics or home management courses in home economics.

550. Seminar in Family Economics and Home Management (1-6) Discussion and reports on developments in family economics and home management.

FOOD SERVICE AND HOUSING ADMINISTRATION

S. Earl Thompson
Head of the Department of Hotel and Institution Administration
4A Home Economics Building

Degrees Conferred: M.S., M.Ed.

Graduate work in this field trains for management positions in institutions which provide food service and housing to large groups, such as hospitals, residence halls, children's homes, and other public and private organizations. For admission, a student should have a baccalaureate degree in this or a related field.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (2)
410. Advanced Quantity Food Production (3)
425. Food and Labor Management and Control (3)
461. Institution Administration (3)
470. Problems in Food Service and Housing Administration (3)

502. Problems in Institution Administration (3-6) Individual study of problems in institution administration. Prerequisites: F.S.H.A. 310, 330.

FOODS AND NUTRITION

George P. Barron, *Head of the Department*
202B Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., and M.Ed in Foods and Nutrition; M.S. in Nutrition in Public Health.
Graduate Faculty: Professors Barron, Gordon, and Pike; Associate Professor Olson.

Graduate programs in foods and nutrition prepare students for careers in college teaching, research, and adult program leadership. The program in nutrition in public health prepares the student for work in public health agencies.

For admission to a graduate program in foods and nutrition, a student must have completed at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 3 in physiology, 4 in other physical and biological sciences, and 8 in foods and nutrition.

For admission to the program in nutrition in public health, the requirements are at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 12 in social sciences, 7 in foods, and 4 in nutrition.

FOODS AND NUTRITION (F N)

400. Special Problems in Foods and Nutrition (1-3)

420. Experimental Cookery (1-6) *Miss Olson*
421. Cultural and Aesthetic Aspects of Food (3) *Mrs. Jennings*
422. Scientific Principles of Food Preparation (3) *Miss Gordon*
426. Recent Developments in Foods (3)
452. Nutritional Aspects of Disease (3) *Miss Pike*
456. Nutrition in the Community (3)
457. Principles of Nutrition (3)
458. Applied Nutrition (2)
459. Advanced Nutrition (3)
490. Foods and Nutrition Seminar (1)

520. Readings in Foods (2) Critical review and reports of literature on selected food topics. *Miss Gordon*

521. Seminar in Foods (1-6) Discussion and reports on current research in the foods field. Prerequisite or concurrent: F.N. 520. *Miss Gordon*

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation. *Miss Gordon*

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition. Prerequisite: F.N. 457.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

552. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy. *Miss Pike*

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. The Survey Method in Foods and Nutrition (2) Study of survey technique as a tool in the assay of food adequacy and nutritional status.

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition. *Miss Pike*

FORESTRY

Peter W. Fletcher
Director of the School of Forestry
102 Forestry Building

Degrees Conferred: M.S., M.F.
Graduate Faculty: Professors Bartoo, Fletcher, McDermott, and Norton; Associate Professors George, Shipman, and Ward; Assistant Professors Gerhold, Hutnik, Lindzey, Murphey, and Sopper.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science. The M.F. and M.S. degrees may be granted in the technological programs and the M.S. degree in the scientific programs.

Attention is called to the Ph.D. programs available in such related fields as agricultural economics, agronomy, botany, entomology, genetics, and plant pathology.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in

timber management, wildlife habitat management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar program emphasizing biological science, economics, and applied mathematics provides the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engineering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

FORESTRY (FOR)

416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
445. Improvements (3)
450. Advanced Mensuration (3)
455. Forest Photo Interpretation (3)
466. Forest Resource Management (3)
469. (W.U. 469) Problems in Forestry and Forest Products (1-6 per term)
480. Policy and Administration (3)

504. (W.U. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 78.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Bot. 409 or 516.

510. Forestry Seminar (1 per term) Current problems of forest research presented as weekly seminar reports. May be repeated with additional credit for each term's work.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerequisite: Bot. 22.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 78, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 70.

WOOD UTILIZATION (W U)

404. Physical and Mechanical Properties of Wood (3)
405. Adhesives and Glued Wood Products (3)
424. Commercial Tropical Woods (3)
435. Seasoning and Preservation (3)
437. Wood Micro-Technique (3)
462. Defects in Wood (3)
469. (For. 469) Problems in Forestry and Forest Products (1-6 per term)
491. Logging and Lumbering (3)
492. Lumber Properties and Usage (3)
495. Lumber Manufacturing Processes and Cost Analysis (3)
497. Small Sawmills (3)

502. Wood Fibres (3) Identification and physical and chemical characteristics of wood fibres used for pulp, either for paper or as a source of cellulose. Pulping quality, fiber measurements.

504. (For. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

510. Wood Utilization Seminar (1 per term)

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

540. Chemical Utilization of Wood (3) Wood as a chemical raw material; its chemical properties and conversion processes.

FRENCH

Lois Boe Hyslop, *Acting Head of the Department*
210 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Belasco, Chapman, Eyer, Hyslop, and LeSage.

The minimum requirement for admission to an advanced degree program will normally be 24 credits of post-intermediate work in language and literature. A

student may follow a graduate program in French literature and in descriptive and historical linguistics with a minor in a related field. M.A. candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

FRENCH (FR)

417. French Phonology (3)
418. French Morphology and Syntax (3)
422. Old French Literature (3)
426. French Literature of the Renaissance (3)
435-436. 17th Century French Literature (3 each)
445. The Age of Enlightenment (3)
451-452. 19th Century French Literature (3 each)
460. French Prose of the 20th Century (3)
461. French Poetry and Drama of the 20th Century (3)
470. Advanced Composition and Conversation (3)
480. The Teaching of French (4)
*489. French Institute (7-14)
491. Problems in French Literature (3-6)
499. Foreign Study in French (3)

† 1G. Elementary French for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

500. An Introduction to Old French (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments.

502. Advanced Linguistics (3) Synchronic dialectology; tagmemic and transformational analysis of contemporary French spoken language and literary texts. Prerequisite: Fr. 418.

515. Medical French Literature (3) Familiarizes the student with Old and Middle French texts from the earliest monuments to Villon.

525. French Renaissance Literature (3-6) The origins and development of French Renaissance literature with emphasis on Rabelais, Ronsard, DuBellay, and Montaigne.

532. French Drama of the Classical Period (3) Origins and development of French classical comedy and tragedy, emphasizing the works of Corneille, Racine and Molière.

533. Seventeenth Century Prose and Poetry (3) The development of Classicism; its apogee and decline as seen in the works of major prose writers and poets.

543. Eighteenth Century French Literature and Thought (3-6) Voltaire, Rousseau, Diderot, and other major figures.

561. French Romanticism (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry.

569. Masters of 20th Century French Literature (3-6) Major literary figures of contemporary French literature.

581. Theory and Techniques of Teaching French (1-3)

* A maximum of 7 credits in one summer.
† No graduate credit is given for this course.

596. Symbolism (3) The anti-positivistic tradition in 19th century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

597. Research Techniques and Bibliography in French Language and Literature (1-3)

598. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

FUEL TECHNOLOGY

Howard B. Palmer, *Head of the Department*
316 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Beér, Given, Palmer, and Walker; Associate Professors Austin, Essenhigh, and Vastola; Assistant Professor Polansky.

In their programs of courses and research, students may emphasize the chemical, physical, or engineering aspects of solid, liquid, or gaseous fuels. Students are accepted with undergraduate majors in chemistry, chemical engineering, mechanical engineering, physics, or fuel technology.

The department has special facilities for research on high temperature gaseous reactions; reactions of free radicals; combustion of pulverized coal and oil sprays; dust explosions; fuel cells; formation, structure, physical properties, and reactions of carbons and graphites; chemistry of coal macerals; reactions in plasmas; structure and reactions of coals; and special organic reactions of fuel-related materials.

Departmental requirements for the doctorate supplement those of the Graduate School with the stipulation that at least 18 credits be earned in departmental courses, out of a total requirement of 54 course credits. Each student is encouraged to develop a strong minor in the field most closely related to his area of specialization in fuel technology.

FUEL TECHNOLOGY (F T)

400. Fuel Technology Research and Design (1-3)
402. Chemicals from Fuels (2) *Mr. Given*
405. Combustion Calculations (3) *Mr. Austin*
406. Gaseous Combustion (3) *Mr. Palmer*
408. Combustion and Gasification Engineering (4) *Mr. Essenhigh*
409. Cokes, Carbons, and Graphites (2) *Mr. Polansky*
410. Fuel Technology Laboratory (2) *Mr. Polansky and Staff*
414. Fuel Engineering Analysis (2) *Mr. Austin*
415. New Sources of Energy (2) *Mr. Vastola*

503. Coalification and Coal Chemistry (3) Chemical changes during the coalification process; chemical and physical constitution and classification of coals; relations between coal chemistry and constitution. Prerequisite: Chem. 31. *Mr. Given*

506. Kinetics of Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of coals and carbons. Prerequisites: Chem. 451, F.T. 409. *Mr. Walker*

510. Special Topics in Fuel Technology (1-6 per term)

511. Fuel Technology Seminar (1 per term) Selected topics from current fuel technology research examined and discussed.

512. High Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.T. 406. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.T. 406. *Mr. Palmer*

515. Catalysis of Fuel Reactions (2) Principles of chemisorption and catalysis; mechanisms of specific catalytic reactions and practical aspects of catalytic processes in the fuels industries. Prerequisite: Chem. 452. *Mr. Walker*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in fuel technology studies are listed under Mineral Sciences.*

GENERAL FAMILY STUDIES

Rose M. Cologne
In Charge of Graduate Programs in General Family Studies
20A Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Because this program is planned for teachers in secondary schools or small colleges and others who wish to become proficient in several areas of home economics, the student must have a strong home economics background for admission.

The major for the M.S. or M.Ed. degree consists of a minimum of 6 credits in each of three areas of home economics. Three areas in this field are also the basis for the major at the doctoral level. However, the minimum credit requirements in each area are established after consultation with a committee which reviews all previous work. The student chooses a minor field of educational foundations or, if sufficient competence in educational foundations is demonstrated, one of the applied fields, such as home economics education, secondary education, or higher education.

GENERAL FAMILY STUDIES (G F S)

410. Communities and Families (3)

516, 516v. Methods of Research in Home Economics (3) Review of problems and techniques of research in home economics. Required of all graduate students in home economics.

GENETICS

James E. Wright, *Chairman of the Committee on Genetics*
307 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate programs are offered in the fields of theoretical and applied genetics, including plant and animal breeding. Courses in genetics and breeding are given by various departments. The basic and theoretical courses are listed under identical

numbers in the Departments of Botany and Zoology. Courses dealing with genetic principles as applied to specific organisms are offered in the Departments of Agronomy, Animal Industry and Nutrition, Dairy Science, Forest Management, Horticulture, Microbiology, and Poultry Science. The graduate committee for majors shall be appropriately represented by members of theoretical and applied phases who shall have the responsibility and jurisdiction for determining course work and research acceptable in satisfying degree requirements.

For entry as a major in this field no fewer than 15 credits in basic biology and 15 credits in the areas of chemistry, mathematics, and physics are required.

The following courses are available in genetics or breeding, and their descriptions may be found under the offerings of the several departments: Agro. 411, 509, 510, 582; A.I. 501, 505; An.Sc. 422; Bot. (Zool.) 405, 422, 505, 524, 528, 533; D.Sc. 513; For. 512; Hort. 444, 501, 514, 520, 524; Micrb. 516; Pty.Sc. 402, 505.

GEOCHEMISTRY

John C. Griffiths
Head of the Department of Geochemistry and Mineralogy
114 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Bates, Brindley, Greig, Griffiths, Keith, Osborn, Roy, Tuttle, and Vand; Associate Professors Barnes, Burnham, Dachille, Thornton, Wright, and Wyllie; Assistant Professors Gibbs and Weber; Mrs. Roy.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOCHEMISTRY (GCHEM)

457. Geochemical Prospecting (2) *Mr. Anderson*

501. Research (1-10 per term) Research in geochemistry.

509. Geochemistry Seminar (1 per term)

510. Problems in Geochemistry (1-9) Laboratory and library study of special problems.

512. Crystal Chemistry of Nonmetallic and Defect Solids (2-4) Relation of structure to ionic size, charge, polarizability; influence of p-t environment; chemical-structural defects, diffusion, transitions, and reactions in solids. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams. *Mr. Wyllie*

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Weber*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Herzog*

518. Isotope-Ratio Variations in Nature (2) Theoretical basis and observations of isotope fractionation in nature: paleotemperature scale; temperatures of formation of ore deposits and other rocks. *Mr. Weber*

519. Cosmochemistry and Nucleogenesis (2) Distribution and composition of matter; origin of solar system and earth, of constituent nuclides, of life. *Mr. Herzog*

520. P-T-X Phase Relations in Mineral Systems (2) Phase equilibrium in mineral systems with pressure as a variable. Prerequisite: Gchem. 513.
Messrs. Tuttle and Wyllie

522. Geochemistry of Aqueous Systems (3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, Po_2-pH relations applied to ground water, sea water, hydrothermal fluids. *Messrs. Barnes and Schmalz*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Mineral Sciences.*

GEOGRAPHY

Allan L. Rodgers, *Head of the Department*
202 Mineral Sciences Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Deasy, Griess, Lewis, Miller, Rodgers, and Zelinsky; Associate Professors Gould, Simkins, and Wernstedt.

The student may concentrate on economic geography, cultural geography, physical geography, one of the major world regions, or acceptable combinations of these fields. In addition, all students receive training in cartographic, statistical, and bibliographic techniques.

Because physical geography is a branch of the physical sciences, and cultural and economic geography are branches of the social sciences, a student may enter graduate work under either of two options. Option 1, for the student who wishes to specialize in physical geography, requires the completion of 18 undergraduate credits in geography and 20 credits in mathematics and biological and physical sciences, including at least 6 credits in geology. Option 2, for the student who wishes to specialize in cultural or economic geography, requires 18 undergraduate credits in geography plus 20 credits in the social sciences, including at least 3 in economics.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Zelinsky*
402. Cultural and Anthropo-geography (3) *Mr. Zelinsky*
405. Geography of Population (3) *Mr. Zelinsky or Mr. Simkins*
407. Geography of Settlement (3) *Mr. Simkins*
410. Cartography—Map Design and Construction (3) *Mr. Deasy*
420. Urban Geography (3) *Mr. Rodgers*
427. Geography of the Soviet Union (3) *Mr. Rodgers*
430. Agricultural Geography (3) *Mr. Whitney*

433.	Regional Climatology (3)	*Mr. Wernstedt*
434.	Regional Physiography (3)	*Mr. Lewis*
442.	Geography of Europe (3)	*Mr. Miller*
443.	Geography of the Orient (3)	*Mr. Whitney*
444.	Geography of Africa (3)	*Mr. Gould*
445.	Geography of Southern Asia (3)	*Mr. Wernstedt*
452.	Interpretation of Afrial Photographs (3)	*Mr. Deasy*
456.	Quantitative Methods of Geographical Analysis (3)	*Mr. Gould*
460.	Political Geography (3)	*Mr. Lewis*
468.	Transportation Geography (3)	*Mr. Gould*
480.	Geography of Manufacturing (3)	*Mr. Miller or Mr. Rodgers*
490.	Physical Geography for Teachers (3)	*Mr. Lewis*

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The literature of some phase of physical geography with emphasis on procedures for organizing material for classroom reports and discussions.

505. Economic Geography Seminar (3-12) The literature of some phase of economic geography with emphasis on procedures for organizing material for classroom reports and discussions.

506. Cultural and Political Geography Seminar (3-12) The literature of some phase of cultural and political geography with emphasis on procedures for organizing material for classroom reports and discussions.

507. Development of Geographic Thought (1-6) Critical analysis of the growth of geographic thought from antiquity to the present; emphasis on structure of modern geography.

510. Physical Geography Research (3-10) Original study in physical geography: a field problem or detailed library investigation with analysis and presentation of data.

511. Economic Geography Research (3-10) Original study in economic geography: a field problem or detailed library investigation with analysis and presentation of data.

512. Cultural and Political Geography Research (3-10) Original study in cultural and political geography: a field problem or detailed library investigation with analysis and presentation of data.

543. Conceptual Frameworks for Geographical Analysis (3) Simulation, topological, queuing, programming, principal component, and game theory models in solving geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

GEOLOGY

Lauren A. Wright
Head of the Department of Geology and Geophysics
110 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Jahns, Lattman, Ridge, Scholten, Spackman, and

Wright; Associate Professors Schmalz and Williams; Assistant Professors Dutcher and Parizek.

Students may specialize in stratigraphy, paleontology, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, marine geology and chemical oceanography, coal geology, and geology of metallic and nonmetallic deposits.

Prerequisites for admission include 25 credits in an approved combination of chemistry, physics, mathematics, and biological sciences, and at least 18 credits in geology and mineralogy.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOLOGY (GEOL)

400. Geology for Teachers (3)
410. Structural Geology (3) *Mr. Wright*
420. Paleobotany (3) *Mr. Spackman*
421. Introduction to Coal Petrology (3) *Mr. Williams*
422. Introductory Palynology (3) *Mr. Spackman*
430. Paleontology (3) *Mr. Guber*
440. Marine Geology (3) *Mr. Schmalz*
451. Economic Geology (3) *Mr. Ridge*
452. Introduction to Hydrogeology (3) *Mr. Parizek*
461. Geology of the United States (3) *Mr. Wright*
462. Principles of Geomorphology (3-6) *Mr. Lattman*
470. Introduction to Field Geology (3) *Mr. Jahns*
472. Field Geology (5) *Mr. Scholten*
481. Geology of Oil and Gas (3) *Mr. Scholten*
490. Paleozoic Stratigraphy (3) *Mr. Williams*
491. Stratigraphy Field Trips (1) *Mr. Williams*
492. Pennsylvanian Stratigraphy (3) *Mr. Williams*

*500. Geology Seminar (1-9) Presentation, at weekly departmental meetings, of topics selected from geological literature.

†501. Stratigraphy (3-12) Principles of stratigraphic classification, lithofacies and biofacies, faunal zonation, correlation, sedimentation, and paleogeography, illustrated by stratigraphy of classical geologic regions: (a) Pre-Cambrian; (b) Paleozoic; (c) Mesozoic; (d) Cenozoic. Prerequisite: Geol. 430. *Mr. Williams*

†503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology.

504. History and Foundations of Geology (2-4) Theoretical aspects of geology; spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought.

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology. *Mr. Lattman*

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

*Credits to be arranged, 1 to 6 per term.
†Credits to be arranged, 3 to 6 per term.

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

515. Ore Microscopy (2-3) Theory and use of the ore microscope in identifying ore minerals in polished section, establishing paragenetic sequences, determining manner of deposition.

‡517. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514.

520. Seminar in Paleobotany (2-6) Current and classic literature concerning evolution, paleoecology, and geologic history of vascular plants. *Mr. Spackman*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Spackman*

526. Problems in Palynology (3-9) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.

530. Geological Problems (1-15) Prerequisite: 10 credits in geology and mineralogy.

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462. *Mr. Lattman*

551. Geotectonics (3-6) Tectonic principles and elements: nature and development of geosynclines, island arcs, mountain structures, stable masses, cratons, mobile belts. *Mr. Scholten*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and microscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks.

571. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

590. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces. Required each spring of all graduate students in geology.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Mineral Sciences.*

GEOPHYSICS

Lauren A. Wright
Head of the Department of Geology and Geophysics
110 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bell and Howell; Associate Professor Herzog; Assistant Professors Lavin and Watson.

‡Credits to be arranged, 2-3 per term.

Students may specialize in geophysical prospecting, seismology, gravity, well logging, tectonics, physical properties of rocks, radioactive age determinations, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, geology, and mineralogy; and at least 12 credits of intermediate-level work in any one or a combination of these subjects.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOPHYSICS (GPHYS)

406. Physics of the Earth (3) *Mr. Howell*
407. Well Logging (3)
408. Geophysical Surveying (3) *Mr. Lavin*
415. Gravity and Magnetic Surveying (3)
416. Electrical Surveying (3)
417. Seismic Methods (3) *Mr. Watson*
418. Potential Theory Applied to Earth Problems (3) *Mr. Watson*

500. Geophysical Seminar (1 per term) Discussion of geophysical reports and papers; scientific outlook.

501. Research (1-10 per term) Research in geophysics.

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders. *Mr. Howell*

503. Special Studies in Geophysics (1-9) Special studies of the theories of geophysical methods.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis. *Mr. Watson*

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting. *Mr. Howell*

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth. *Mr. Howell*

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration. *Messrs. Herzog and H. D. Wright*

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineral Sciences.*

GERMAN

Albert F. Buffington, *Acting Head of the Department*
229 Sparks Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Professors Buffington, de Levie, Ebbinghaus, and Shelley; Associate Professors Beare, Lüders, and Striedieck.

There is opportunity for major emphasis upon either literature or philology. Minimum qualifications for admission include 18 undergraduate credits in German; provision is made, however, for admission with limited deficiencies.

A thesis is required of all M.A. candidates in this major.

GERMAN (GER)

401. Advanced Stylistics (3)
430. History of the German Language (3)
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3)
469. Goethe's Life and Works (3)
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

524. Old Saxon (3) Introduction to Old Saxon grammar; readings in Old Saxon texts, both prose and poetry. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

*No graduate credit is given for this course.

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

HIGHER EDUCATION

Hugh S. Brown, *in Charge of Graduate Programs in Higher Education*
113 Education and Psychology Center, Building II

Degrees Conferred: D.Ed., M.Ed.
Graduate Faculty: Professors Brown, Edgar, Patrick, and Wellington.

Graduate students with any undergraduate major may enter the program without other prerequisites. The following courses in higher education are listed under the offerings of the Department of Educational Services: Ed.Ser. 545 to 552 inclusive and 555 (see page 98). To complete a program to meet the student's needs, additional courses will be selected from other departments of the University.

This program is designed to prepare candidates for such positions as college instructor in professional education, college administrator, director of special divisions in education, or educational research worker. It is not open to students who are preparing to give instruction in such subject-matter areas as the arts, humanities, natural sciences, or social sciences However, candidates for advanced degrees in fields other than higher education may elect it as a minor, subject to the restrictions concerning minors.

Candidates who have not had teaching experience or other approved educational experience will be required to complete an approved apprenticeship before the degree will be conferred.

HISTORY

Robert K. Murray, *Head of the Department*
116 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Brown, Dahmus, Forster, Gray, Klein, McNall, Murray and Pundt; Associate Professors Ameringer, Green, Hassler, Hoogenboom, Meier, and Thaden; Assistant Professors Frantz and Pixton.

Graduate work is offered in the following fields of history: ancient, medieval, early modern European, modern European, colonial American, 19th century American, modern American, British, Russian, Latin American, Far Eastern, Middle Eastern, political (European or American), diplomatic (European or American), economic (European or American), social and cultural (European or American).

The candidate for the doctor's degree must pass examinations in four of the above fields, one of which is his dissertation field. He must also pass an examination either in a fifth field of history and a single cognate field, or in a study area made up of a number of academic disciplines related to his dissertation field. The candidate for the master's degree selects one broad field (such as modern European or American) for examination and thesis purposes. About half his course credits are selected outside

the examination field. He also must take work in a cognate field. A thesis is required of all M.A. candidates in this major.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. All applicants should provide Graduate Record Examination scores with their applications. All prospective doctoral applicants must supply GRE scores.

HISTORY (HIST)

401.	Ancient Civilization (3)	*Mr. Borza*
403.	The Middle Ages from Constantine to the Crusades (3)	*Mr. Dahmus*
404.	The Middle Ages from the Crusades to the Renaissance (3)	*Mr. Dahmus*
408.	Intellectual History of the Middle Ages (3)	*Mr. Dahmus*
410.	Renaissance and Reformation (3)	*Mr. Green*
413.	The Age of Absolutism (3)	*Mr. Green*
417.	Nineteenth Century Europe (3)	*Mr. Forster*
419.	Recent European History (3)	*Mr. Forster*
422.	History of the American Frontier (3)	*Mr. McNall*
425.	History of American Political Parties (3)	*Mr. Hoogenboom*
427.	The Diplomatic History of the United States (3)	*Mr. Ameringer*
428.	American Military History (3)	*Mr. Hassler*
431.	Colonial and Revolutionary America (3)	*Mr. Frantz*
432.	The Formative Period of American History (3)	*Mr. Brown*
433.	The Middle Period of American History (3)	*Mr. Klein*
434.	The United States in Civil War and Reconstruction (3)	*Mr. Hassler*
435.	The Emergence of Modern America (3)	*Messrs. Murray and Hoogenboom*
436.	Recent American History (3)	*Mr. Murray*
440.	History of England, 1485-1760 (3)	*Mr. Linker*
441.	English History Since 1760 (3)	*Mr. Linker*
442.	History of Russia to 1801 (3)	*Mr. Thaden*
443.	History of Russia, 1801-1917 (3)	*Mr. Thaden*
444.	Eastern Europe in Modern Times (3)	*Mr. Thaden*
447.	Social and Economic History of Europe Since 1750 (3)	*Mr. Pundt*
448.	Intellectual and Cultural History of Modern Europe (3)	
449.	Diplomatic History of Europe Since 1870 (3)	*Mr. Forster*
452.	Social and Cultural History of the United States Since 1783 (3)	*Mr. Brown*
454.	Economic Development of the United States (3)	*Mr. McNall*
456.	History of American Labor (3)	*Mr. McNall*
460.	Latin America and the United States (3)	*Mr. Gray*
461.	Social and Cultural History of Latin America (3)	*Mr. Gray*
471.	History of Modern China (3)	*Mr. Johnson*
472.	Twentieth Century China (3)	*Mr. Johnson*
481.	The Middle East in Modern Times (3)	
491.	History of the Soviet Union (3)	*Mr. Enteen*

501.	Historical Method (3)	*Mr. Klein*
502.	Historiography (3)	*Mr. Pundt*
504.	Medieval Civilization (3-9)	*Mr. Dahmus*
505.	The Age of the Reformation (3-6)	*Mr. Green*
508.	Studies in European History, 1600-1789 (3-6)	*Mr. Pundt*
509.	Europe Since 1789 (3-6)	*Mr. Forster*

512. Studies in Pennsylvania History (3-6) *Mr. Klein*

520. Colonial and Revolutionary America (3-6)

533. The United States, 1783-1860 (3-6) *Mr. Klein*

534. The United States, 1860-1900 (3-6) *Messrs. Brown and Hassler*

536. The United States in the 20th Century (3-6) *Messrs. Murray and Hoogenboom*

538. Diplomatic History of the United States (3)

539. Economic History of the United States (3) *Mr. McNall*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6)

545. Studies in Russian and Slavic History (3-6)

550. Problems in History (3-6)

562. Seminar in Latin-American History (3-6) *Mr. Gray*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Gray*

599. Readings in History (1-6)

HOME ART

William J. McHale, *Chairman of the Division*
258 Home Economics South

A candidate for an advanced degree may choose a minor in home art upon approval by his major department. However, no advanced degree is offered in this field.

FAMILY HOUSING AND HOME ART (FH HAR)

401. Home Furnishings for the Family (3)
*433. Advanced Home Crafts (2-12)
440. Advanced Home Furnishing Problems (3)
441. Special Problems in Home Furnishings (3)
470. Housing Problems and Policies (3)

515. Backgrounds of the Home Arts (3) Evaluation of useful objects in respect to their form, function, and time; selections for exhibition. Prerequisites: Art 15 or A.Ed. 106, and Art H. 1 or F.H.H.Ar. 240.

530. Problems in Family Housing and Home Art (1-6) Individual investigation, analysis, and presentation.

541. Art in the Environment (3) Approach based upon human needs with consideration of materials in the light of their use in home living. Prerequisite: Art 14 or A.Ed. 105 or F.H.H.Ar. 440.

*Not more than 2 credits in each field.

HOME ECONOMICS EDUCATION

MARJORIE EAST, *Head of the Department*
116B Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors East, Hatcher, and Henderson; Associate Professor Ray.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

For admission the student must present approximately 50 credits of undergraduate work from the following areas: home economics education, education and/or psychology, aspects of home economics; the physical and biological sciences; and the social sciences.

HOME ECONOMICS EDUCATION (HE ED)

406, 406v. AUDIO-VISUAL METHODS FOR HOME ECONOMICS (1-4)
427, 427v. TEACHING HOME ECONOMICS (3)
443, 443v. ADULT EDUCATION IN HOME ECONOMICS (3)
463, 463v. SENIOR SEMINAR (2)
*466, 466v. STUDENT TEACHING (9)
477, 477v. CURRICULUM DEVELOPMENT FOR HOME ECONOMICS IN SECONDARY SCHOOLS (3)
478, 478v. APPRAISING STUDENT PROGRESS IN HOME ECONOMICS (3)
479, 479v. READINGS IN HOME ECONOMICS EDUCATION (1-4)
480, 480v. PROBLEMS IN TEACHING HOME ECONOMICS (3-6)

502, 502v. HOME ECONOMICS INSTRUCTION AT THE COLLEGE LEVEL (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers. *Mrs. East*

503, 503v. HOME ECONOMICS TEACHER EDUCATION (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics. *Miss Hatcher*

504, 504v. EDUCATIONAL ISSUES AND HOME ECONOMICS (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience. *Mrs. East*

510, 510v. EDUCATIONAL LEADERSHIP IN HOME ECONOMICS (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education curriculum and two years' teaching experience in home economics. *Mrs. East*

518, 518v. EVALUATION OF HOME ECONOMICS PROGRAMS (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision. *Miss Hatcher*

521, 521v. HOME ECONOMICS EDUCATION SEMINAR (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

*A grade point average of 2.2 in all previous work is prerequisite to each course in student teaching.

526, 526v. The Community Program in Family Life Education (2-3) Ways of discovering community needs and resources; methods of developing the community program in family living; leadership education for the lay member of the community.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE

Darrell E. Walker, *Head of the Department*
101 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Fleming, Hitz, Larson, Mastalerz, Meahl, Odland, and Walker; Associate Professors Bergman, McArdle, Ritter, Smith, and Tukey; Assistant Professors Craig, Creech, Haramaki, and Pfahl.

Students may specialize in propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various physiological studies of horticultural crop species.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, or plant nutrition and pomology should register for Hort. 501.

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, and biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

HORTICULTURE (HORT)

412.	Storage of Horticultural Crops (3)	*Mr. Ritter*
424.	Advanced Olericulture (3-6)	*Mr. Odland*
425.	Advanced Fruit and Vegetable Processing I (3)	*Mr. McArdle*
426.	Advanced Fruit and Vegetable Processing II (3)	*Mr. McArdle*
427.	Advanced Floriculture (3)	*Mr. White*
428.	Advanced Floriculture (3)	*Mr. Mastalerz*
444.	Advanced Plant Breeding (3-6)	*Mr. Craig*
447.	Problems in Horticulture (1-9)	
450.	Fruit Science (3)	*Mr. Ritter*
451.	Flower Store Management (4)	*Mr. Pfahl*
453.	Nursery Principles and Practice (3)	*Mr. Brewer*
456.	Problems in Nursery Practice (3)	*Mr. Brewer*

500. Ecology of Fruit Plants (3) Factors limiting the distribution and intensity of culture of fruit species and varieties and effect of environmental factors on cultural practices. Spring term, even years. *Mr. Tukey*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology. *Mr. Hitz*

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. Winter term, odd years. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Mr. Meahl*

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3)

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years. *Mr. Tukey*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

INDUSTRIAL ARTS EDUCATION

John Withall, *Head of the Department of Secondary Education*
168 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professor McGarey; Associate Professor Pendered.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission.

INDUSTRIAL ARTS (I ART)

400. Shop Management and Layout (3)
407. Curriculum Materials and Methods in Industrial Arts (4)
470. Problems in Senior High School Industrial Arts (3)

574. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. Problems in Industrial Arts Education (2-3) Subject matter, projects, methods of manual and informational teaching, aids and devices, selection of text and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. Testing in Industrial Arts (2-3) Construction of informal manipulative and

written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and grading; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. Seminar in Industrial Arts (2-9) Directed intensive study, investigation, or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING

Benjamin W. Niebel, *Head of the Department*
207 Hammond Building

Degrees Conferred: M.S., M.Eng.
Graduate Faculty: Professors Niebel, Lancaster, Schmidt, Williamson, and Thuering; Assistant Professors Draper, Ham, and Raphael.

Graduate study and research are conducted in management science, process design, systems engineering, and human engineering.

For admission a student must have been graduated from an accredited school with a major in industrial engineering. Graduates of other accredited engineering majors may be admitted after completing basic work in industrial engineering.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
402. Engineering Economy (3)
404. Management Science (3)
405. Quantitative Methods in Industrial Engineering III (3)
406. Design of Production Systems (3)
422a,b,c,d,e,f. Industrial Engineering Problems (2-12)
423. Quality Control (3)
424. Job Evaluation (3)
425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Advanced Metal Casting (3)
428. Foundry Engineering (3)
430. Industrial Leadership (3)
432. Industrial Engineering Lectures (1-3)

501. Manufacturing Methods (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. Management Methods (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. Industrial Relations (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with

emphasis on inference and testing of hypotheses. Prerequisites: Math. 43 and 3 credits in statistics.

508. Methods of Operations Research (3) Analytical approach to management decision-making including decision theory, game theory, constrained extremum theory; minimum cost transportation and network models. Prerequisites: Math. 100 and 3 credits in statistics.

509. Methods of Operations Research (3) Theory and application in decision-making including sequencing, line balancing, inventory, replacement, waiting line models, and Monte Carlo simulation. Prerequisites: Math. 100 and 3 credits in statistics.

510. Methods of Operations Research (3) Theory and application of mathematical programming including linear and dynamic programming, and an introduction to nonlinear, integar, and stochastic programming. Prerequisite: Math. 100.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 44 and 3 credits in statistics.

513. Data Processing and Programming (3) Theory and techniques in systems analyses applied to the programming of procedures and operations.

JOURNALISM

Robert M. Pockrass, *in Charge of Graduate Programs in Journalism*
211 Carnegie Building

Degree Conferred: M.A.
Graduate Faculty: Professors Brown, Goodwin, and Marbut; Associate Professors Froke, Harrison, Norris, and Pockrass.

The program is designed to give students a critical insight into the theory and practice of communication and the mass communications industries, as well as an introduction to research on communications problems. Fulfilling the requirements for this degree should qualify students to advance in positions of responsibility and leadership in the professions of journalism, advertising, broadcasting, and public relations; in communications research; or in education.

The program is designed for students who have a groundwork of technical and professional education or experience in journalism and communications. Such students are admitted under Plan A. Students lacking a knowledge of the fundamentals of journalism and communications may enroll under Plan B and be required to take up to 18 credits in basic courses needed to make up this deficiency.

A thesis is required of all M.A. candidates in this major.

JOURNALISM (JOURN)

401. Critics and Ethics of the Mass Media (2) *Mr. Harrison*
405. Comparative Foreign Journalism (2) *Mr. Marbut*
406. Evaluation and Uses of Mass Communications Research (3) *Mr. Preston*
421. Editorial Interpretation (3)
422. Cultural Aspects of the Mass Media (3) *Mr. Pockrass*
424. Public Affairs Reporting (4) *Mr. Dulaney*
430. Journalism in the Schools (3-6) *Mr. Vairo*
441. Advanced Advertising Copywriting (3)

443. Advertising Campaigns (3) *Mr. Rotzoll*
444. Advertising in Contemporary Society (3) *Mr. Norris*
466. Public Relations Problems (3)
468. Law of Mass Communications (3) *Mr. Smith*
480. Media Management (3)
485. Comparative Theories of Press Systems (3) *Mr. Norris*
492. (Brcst. 492) Public Affairs Broadcasting (3) *Mr. Froke*
499. Independent Study in Mass Communication (2-6) *Mr. Goodwin*

504. Seminar in the History of Mass Communications (3) *Mr. Marbut*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes. *Mr. Marbut*

506. Seminar in Communications Research (3-6) Methodology of research in media, content, audiences; experimental, case, and field studies; data processing and analysis; report writing; individual projects. *Mr. Preston*

508. The Literature of Journalism (3) *Mr. Brown*

513. Current Problems in News Reporting and Editing (3) Securing, writing, display, and treatment of the news; newsroom policies and ethics. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Goodwin*

540. Seminar in Advertising Problems (3) *Mr. Norris*

MATHEMATICS

James B. Bartoo, *Head of the Department*
230 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors R. Ayoub, Bartoo, Benton, Curry, A. Frink, O. Frink, E. Johnson, Kanwal, H. Krall, Mitchell, Mrowka, Ribeiro, Schoenfeld, and Sheffer; Associate Professors Anderson, C. Ayoub, Harkness, Howard, Hunter, D. G. Johnson, Kist, Mack, and McCammon; Assistant Professors Barnes, Rung, and Stevens.

Graduate courses in all the principal branches of mathematics are offered each year. The department is prepared to direct research in a variety of fields, including function theory, abstract algebra, topology, number theory, statistics, numerical analysis, computer science, applied mathematics, and all aspects of mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

To be admitted to the M.A. or Ph.D. program without undergraduate deficiency, an applicant should have completed at least three courses in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) and 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree.

For the M.A. degree the department permits the substitution, in place of the thesis, or a term paper and a written examination based on the content of Math. 420-421, 480-481, 473, 501, and 508. The term paper may be one of the following types: (a) a small piece of mathematical research, (b) an expository paper on some area of mathematics, or (c) an expository paper on a narrower area which is to exhibit a sound knowledge of the literature and the use of library sources, and which is to be completed in a 10-week period.

The written examination mentioned above is also required of graduate students who have not taken their master's degree at this University. It, together with one language examination in French, German, or Russian, must be passed by all M.A. and Ph.D. candidates before they have scheduled more than 48 graduate credits. Failure to fulfill these requirements will result in the dismissal of the student.

All first-year students who are candidates for the M.A. or Ph.D. degrees are required to enroll in a special seminar course.

To be admitted to the M.Ed. program without undergraduate deficiency in mathematics, an applicant should have at least 24 credits in mathematics including at least 6 at the intermediate level beyond calculus.

Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 415, 416, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. and D.Ed. degrees.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402 Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. Fourier Series and Boundary Value Problems (3)
407. Foundations of Alegebra and Geometry (3)
409-410. Probability and Statistics (3 each)
411. Finite Differences (3)
413-414. Mathematics of Science for Teachers (3 each)
415. Survey of Modern Mathematics for Teachers (3)
416. Mathematical Logic for Teachers (3)
417. Vector and Tensor Analysis (3)
419. Analytical Mechanics (3)
420-421. Introduction to Analysis (3 each)
428. (Phil. 428) Logical Theory (3)
431. Differential Equations (3)
441. Matrix Algebra (3)
451-452. Introduction to Applied Mathematics (3-6 each)
453. Mathematics for Digital Computers (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elements of Set Theory and Topology (3)
480-481. Introduction to Modern Algebra (3 each)
491. Topics in Applied Mathematics (3-9)
498. Mathematics Seminar (1-6)

500. Analytical Mechanics (3) An exposition of rigid dynamics, the potential function, and Lagrange's equations. Prerequisite: Math. 419 or Phys. 461.

501-502. Theory of Functions of a Real Variable (3 each) Theory of real functions, sets, measure, derivatives, and integrals. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisites: Math. 44, 421.

508-509. Theory of Functions of a Complex Variable (3 each) Development of the complex number system; theory of analytic functions. Prerequisite: Math. 421.

510. Theory of Groups (3) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisites: Math. 480, 441; or Math 481.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite. Math. 421.

516-517. Advanced Probability Theory (3 each) Probability spaces, distribution functions, characteristic functions, convergence theorems, independence, central limit problems, dependence, stochastic processes. Prerequisite: Math. 501.

520-521. Projective Geometry (3 each) General study of the subject from the postulational standpoint. Prerequisite: Math. 43. Alternate years or as required.

522-523. Metric Differential Geometry (3 each) The usual classical treatment of the subject. Prerequisite: Math. 43.

530-531. Topology (3 each) Topological spaces, combinatorial topology, applications to algebra and analysis.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. (Phil.) 428.

534. Theory of Algebraic Numbers (3) Introduction to the number theory of quadratic fields, with study of the theory of ideals in quadratic and higher fields, with application. Prerequisites: Math. 404, 480.

535. Modern Algebra (3) First graduate course in abstract algebra including the basic theory of semigroups, rings, fields, operator groups, and factorization. Prerequisites: Math. 480, 441; or Math. 481.

537. Theory of Fields (3) Selected topics from field theory including extensions and structure of fields; Galois theory; algebraically closed, ordered, and algebraic number fields. Prerequisite: Math. 535.

538. Theory of Rings (3) Selected topics from commutative and noncommutative ring theory including ideals, the Jacobson structure theory, and special classes of rings. Prerequisite: Math. 535.

539. Lattice Theory (3) Selected topics from lattice theory including complete, modular, complemented, and distributive lattices and applications. Prerequisite: Math. 535.

542-543. Theory of Statistics (3 each) Univariate and multivariate distributions, sampling distributions, theory of estimation, statistical hypotheses. Prerequisites: Math. 409, 421.

550-551. (Phil. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Math. (Phil.) 428.

552-553. Numerical Analysis (3 each) Topics from: interpolation and integration with remainder terms; approximation theory; asymptotic expansion; solutions of algebraic, differential, integral equations. Prerequisites: Math. 421, 453.

554. (Phil. 554) Metamathematics (3) Prooftheoretic and modeltheoretic study of systems: Gödel's theorem, relative and absolute consistency proofs, decidability, properties of relational structures, mathematical applications. Prerequisite: Math. (Phil.) 428.

555. Selected Topics in Mathematics for Chemists (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions.

556. (Phil. 556) Recursion Theory (3) Recursive functions; recursive and recursively enumerable sets; equivalent formulations of computability; Church's thesis; related topics from current literature. Prerequisite: Math. (Phil.) 428.

560-561. Theory of Differential Equations (3 each) Prerequisites: Math. 44, 421.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 501.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. Special Topics in Probability and Statistics (3-12)

578. Special Topics in Topology (3-12)

MECHANICAL ENGINEERING

Richard G. Cunningham, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus.)
Graduate Faculty: Professors Ambrosius, Brickman, Calvert, Cunningham, Dillio, Meyer, Olson, Queer, and Shearer; Associate Professors DeCarolis, Lestz, McLaughlin, and Schmidt; Assistant Professors Heinsohn and Margolis.

Graduate programs and research facilities are available in dynamic system analysis and instrumentation, automatic controls, fluid amplifiers, combustion and ignition processes, heat transfer, thermodynamics, fluid mechanics, turbulence, machine dynamics, advanced design engineering, lubrication, power generation and utilization, and building research studies. In addition to basic facilities in the mechanical engineering laboratory, the department has several specialty research laboratories. They are:

Systems and Controls Laboratory, Air Environment Laboratory, Dynamics Simulation Laboratory, and Automotive Safety Research Laboratory.

The entering student must hold a bachelor's degree in engineering or physical science. If his undergraduate work has not included considerable work in mechanical engineering subjects, he may be required to include these subjects in his program.

MECHANICAL ENGINEERING (M E)

401. Mechanical Engineering (3-12)
402. Air Conditioning (3)
403. Rocket Propulsion (3)
404. Thermodynamic Systems (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration (3)
412. Heat Transfer (3)
413. Internal Combustion Engines (3)
417. Theory of Engineering Istruments (3)
418. Principles of Turbomachinery (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Design Analysis (3)
453. Bearing Design and Lubrication (3)
455. Automatic Control Systems (3)
457. Advanced Mechanisms (3)

502. Advanced Gas Turbines (3-6) Analytical study of gas turbine compressors and turbines; combustion; complex cycles; recent developments. Prerequisite: M.E. 409.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. Selected Topics in Mechanical Engineering (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Advanced Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions. Prerequisites: M.E. 412, Math. 451.

513. Advanced Heat Transfer—Convection and Radiation (3) Convection heat transfer in laminar and turbulent flow; two-phase heat transfer, transportation, film and ablation cooling, and radiation heat transfer. Prerequisite: M.E. 412.

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; two-dimensional supersonic flow; oblique shock waves.

520. Nonsteady Flow of Compressible Fluids (2-4) Method of characteristics; general flow problems; boundaries and discontinuities; interaction of discontinuities; wave diagram techniques and applications.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses

produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) The hydrodynamic theory of lubrication and methods of applying it to bearing design, together with a survey of methods of testing lubricants.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

557. Mechanism Synthesis (3) Design and analysis of mechanisms for specific motion and energy requirements; intermittent mechanisms. Prerequisite: M.E. 457.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY

Robert W. Lindsay, *Head of the Department*
5 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Lindsay, Muan, and Read; Associate Professors Bitler, Healy, Hoke, and Simkovich; Assistant Professor Ryba.

There is opportunity for a student to specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

To be prepared for the graduate program, the applicant should present a bachelor's degree in metallurgy or metallurgical engineering, or a satisfactory bachelor's degree in any other field which has included mathematics through ordinary differential equations; a year of basic physics; three courses in chemistry, including laboratory and covering inorganic chemistry and preferably physical chemistry; and three courses in metallurgy. Students who lack some of this background can be admitted but will be expected to make up their deficiency without receiving graduate credit.

METALLURGY (METAL)

405. Ferrous Metallography (3)
406. Nonferrous Metallography (3)
407. Metallurgical Engineering I (3)
408. Metallurgical Engineering II (3)
409. Metallurgical Investigations I (2)
410. Metallurgical Investigations II (2)
412. Solid State Metallurgy (3)

501. Metallurgical Problems (1-6 per term) Independent study of special problems in metallurgy. *Mr. Bitler*

502. Seminar in Metallurgy (1-6) Conferences, reading, reports, and special lectures.

508. Kinetics of Phase Transformations (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. Introductory Theoretical Physical Metallurgy (3) Quantum mechanics and its application to solid state theory; introduction of Schroedinger's equation, its solutions, free electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452; Metal. 301, 302, 304. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. Prerequisites: Metal. 511, 513. *Mr. Read*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 513. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisites: Metal. 511, 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Chem. 452 or Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513. *Mr. Lindsay*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 511, 513. *Mr. Ryba*

525. Metal Finishing (3) Metallic coatings and their metallurgical properties; theories and problems of application, utilization, and evaluation. Prerequisite: Metal. 515. *Mr. Read*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Mineral Sciences.*

METEOROLOGY

Charles L. Hosler, Jr., *Head of the Department*
322 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Blackadar, Hosler, Neuberger, and Panofsky; Associate Professors Danielsen, Duquet, and Stephens.

Candidates in meteorology may specialize in aerosol and cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, atmospheric optics and electricity, macro- and microclimatology, agricultural meteorology, synoptic meteorology, or meteorological instrumentation.

Requirements for admission include mathematics through differential equations and one year of college physics. Students with a strong background in mathematics, physics, or engineering may be admitted with deficiencies but must make up such deficiencies before they are admitted to candidacy for a degree.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
411. Introduction to Synoptic Meteorology (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
443. Physical Meteorology (3)
445. Hydrometeorology (3)
450. Applications of Statistics to Meteorology (3)
451. Thermodynamics of the Atmosphere (3)
452. Hydrodynamics of the Atmosphere (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
492. Meteorological Seminar (1-2)

500. Meteorlogical Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Mineral Sciences.*

MICROBIOLOGY

Robert W. Stone, *Head of the Department*
204 Patterson Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Cone, Dunne, Gentry, Lindstrom, Ludwig, Stone, and Zimmerman; Associate Professors Casida and Heist; Assistant Professor Pootjes.

Specialized areas of study include microbial physiology, soil microbiology, food and industrial microbiology, microbial genetics, immunology, bacteriophage, and virology. There is opportunity for research in animal disease in cooperation with the Department of Veterinary Science.

Prerequisites for admission are 20 credits in chemistry including quantitative analysis and organic chemistry, 6 in physics, and 8 in microbiology. Mathematics through calculus is recommended. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work.

MICROBIOLOGY (MICRB)

401. General Microbiology (4)
407. Problems in Microbiology (1-12)
410. Immunology and Serology (4)
411. Survey of Microbiology (1 per term)
412. The Bacterial Pathogens (4)
413. Soil Microbiology (3)
414. Food Microbiology (4)
416. Industrial Microbiology (4)
417. Epidemiology (2)

507. Seminar (1 per term) Reports on current fields of research.

508. Physiology of Bacteria (2-4) Composition, nutrition, and growth of microorganisms; influence of physical and chemical environment on metabolism.

509. Fermentation (2) Chemical activities of microorganisms; mechanisms of fermentative and oxidative metabolism.

512. Bacteriological Techniques (1-6) Practice in special laboratory techniques including manometry, tissue culture, and serology.

515. (V.Sc. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

MINERAL ECONOMICS

JOHN D. RIDGE, *Head of the Department*
207 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Ridge and Schanz; Associate Professor McDivitt.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in commodity analysis (fuels, metals, or nonmetals), resource economics (mineral policy or area studies), industrial economics (administration, market research, or financial analysis), or operations research and statistics (resource allocation, forecasting, or exploration programming).

The requirements for admission are 24 credits in chemistry, physics, mathematics, or statistics; 12 credits in the earth sciences; 9 credits in economics, mineral economics, commerce, business administration, or industrial management; and 6 credits in engineering subjects.

Students having a deficiency of 9 credits or fewer in this total of 51 may be admitted as regular graduate students but will be required to make up such deficiencies without the credits being applicable toward the advanced degree.

In addition to the normal degree requirements of the Graduate School, students receiving the M.S. degree must have a minimum of 9 credits of economics (including courses used for admission) and must pass an oral defense of their thesis. Doctoral candidates must complete at least 15 credits of economics (including courses used for admission). The comprehensive examination for the doctorate includes written examinations on the major and minor fields in addition to the oral examination required by the Graduate School.

MINERAL ECONOMICS (MN EC)

400. SEMINAR (1)
453. NONMETALLIC MINERALS (3)
483. THE METALS AND THEIR ORES (3)
484. ECONOMICS OF ENERGY RESOURCES (3)
486. PETROLEUM AND NATURAL GAS ECONOMICS (3)
490. MINERAL VALUATION (3)
491. ANALYSIS OF MINERAL DATA (2)

500. ADVANCED PRINCIPLES OF MINERAL ECONOMICS (3-6) Mineral history, research methods in mineral economics, applications of economic theory, mineral policy problems, economics of mineral exploitation, selected readings.

501. ADVANCED STUDIES IN MINERAL COMMODITIES (3-6) Case studies of economic or industrial problems, or both, of selected mineral commodities. Prerequisites: 3 credits in Mn.Ec. 500 and at least 3 credits in Mn.Ec. 453, 483, 484, or 486.

502. TECHNOLOGIC INFLUENCES (3-9) Relationship of technologic advancements to economic development of the mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

505. PROBLEMS IN MINERAL ECONOMICS (3-12) Individual research involving library, laboratory, or field work to develop solutions to selected techno-economic problems of the mineral industries. Prerequisite: Mn.Ec. 500.

590. MINERAL ECONOMICS SEMINAR (1 per term) Preparation and presentation of papers on advanced problems. Required each term in residence.

MINERAL PREPARATION

HAROLD L. LOVELL, *Acting Head of the Department*
4 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Spicer and Sun; Associate Professor Lovell.

Areas in which students may specialize include the fundamentals of gravity, electrical, and chemical methods of beneficiating natural mineral deposits. Graduate work may also be undertaken on the properties of specific minerals as they are related to beneficiation.

Graduates with a bachelor's degree in such scientific fields as chemistry, physics, and mathematics, and in such engineering fields as mining, metallurgy, ceramics, fuel technology, and mechanical, electrical, and civil engineering are eligible for admission. However, graduates in the above fields are required to take 6 credits of undergraduate courses in mineral preparation along with their graduate program.

MINERAL PREPARATION (MN PR)

401. ADVANCED MINERAL PREPARATION LABORATORY (1)
404. PLANT LAYOUT AND DESIGN (3)
410. COAL PREPARATION (3)
420. UNIT OPERATIONS (3)
430. FLOWSHEETS OF MINERAL PREPARATION PLANTS (3)
457. FIELD TRIP (1-2)

502. FROTH FLOTATION AND AGGLOMERATION (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 420. *Mr. Sun*

504. MINERAL PREPARATION RESEARCH (1-6 per term) Research work on specific problems in mineral preparation. Prerequisite: Mn.Pr. 410 or 420.

505. GRAVITY PROCESSES AND MISCELLANEOUS METHODS OF MINERAL PREPARATION (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and dense-media processes of mineral concentration. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

506. MINERAL PREPARATION PLANT DESIGN (3-10) Layout, design, and selection of equipment for specific mineral preparation plant projects. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

507. CHEMICAL PROCESSES OF MINERAL PREPARATION (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Mn.Pr. 420. *Mr. Lovell*

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineral preparation studies are listed under Mineral Sciences.*

MINERALOGY AND PETROLOGY

JOHN C. GRIFFITHS
Head of the Department of Geochemistry and Mineralogy
114 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bates, Brindley, Greig, Griffiths, Keith, Osborn, Roy,

Tuttle, and Vand; Associate Professors Barnes, Burnham, Dachille, Thornton, Wright, and Wyllie; Assistant Professors Gibbs and Weber; Mrs. Roy.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, mineralogy, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography (i.e., an equivalent to Min. 485, acceptable to the faculty). Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

MINERALOGY (MIN)

413. Scientific Method Applied to the Earth Sciences (3) *Mr. Griffiths*
463. Optical Mineralogy (2) *Mr. Wright*
464. Optical Mineralogy (1) *Mr. Wright*
483. Petrology (2) *Mr. Thornton*
484. Petrology (2) *Mr. Griffiths*
485. Petrology (2) *Mr. Thornton*

500. Optical Crystallography of Minerals (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 464. *Mr. Wright*

501. Petrology (3-6) Microscopic study of rocks, emphasizing classification and genetic relationships. *Messrs. Tuttle, Wyllie, and Griffiths*

502. Mineralogical Problems (3) Original study of some limited mineralogical or petrological problems.

504. Theoretical Mineralogy (3) Crystal chemistry and crystal physics applied to solid solution, polymorphism, crystal growth, and related phenomena. *Mr. Bates*

505. Mineralogy Seminar (1-2) Reading, presentation, and discussion of literature dealing with various phases of theoretical mineralogy. Topics are selected to meet the interests of the majority of the students.
Messrs. Tuttle, Bates, Griffiths, Wright, Wyllie, Vand, Brindley, and Burnham

*510. Metamorphic Petrology (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484, 485. *Mr. Wyllie*

511. Sedimentary Petrology (3-4) Composition, texture, structure, mass properties of sediments; dynamic processes in complex natural systems; sedimentary stages: weathering, erosion, transport, deposition, lithification. Prerequisites: Min. 483, 484, 485. Concurrent: Min. 513.

512. Sedimentary Petrology, Continued (2-4) Diastrophism and tectonic background of sedimentation; depositional loci; classification of sediments: quartzites, graywackes, arkoses; chemical sediments; paleogeography, paleoclimatology, oil finding. Prerequisite: Min. 511. Concurrent: Min. 514.

*Credits to be arranged, 2-4 per term.

513. Methods of Analysis of Sediments (3) Principles and practices used in analyzing sedimentary rocks for size, shape, and accessory (heavy) minerals. Concurrent: Min. 511. *Mr. Griffiths*

514. Applied Sedimentology (3) Design and control in analysis of sedimentary rocks; application of these techniques to industrial problems. Concurrent: Min. 512. *Mr. Griffiths*

520. Study of Accessory Minerals (2-4) Detailed study of accessory (heavy) minerals; their significance in problems of provenance, petrogenesis, mineral stratigraphy, and paleogeography. Prerequisites: Min. 511, 512, 513, 514. *Mr. Griffiths*

524. Introduction to Sedimentation (3) Prerequisites: Min. 483, 484. Concurrent: Min. 485.

525. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 485, 500, 527. *Messrs. Tuttle and Thornton*

526. Statistical Problems in Sedimentary Geology (3) Application of experimental design, sampling procedures, multiple regression and discriminant analysis in solving problems in sedimentary petrography. Prerequisites: Min. 514; Math. 410 or Agro. 545. *Mr. Griffiths*

527. Igneous and Metamorphic Mineralogy (3) Structural and compositional variations of minerals in igneous and metamorphic rocks. *Messrs. Jahns and Gibbs*

529. Radioactivity in Rocks (1-2) Distribution, mineralogy, and petrology of the radioactive elements. *Mr. Wright*

530. (Cer.T. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Griffiths, Bates, and Brindley*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Mineral Sciences.*

MINING ENGINEERING

Robert Stefanko, *Head of the Department of Mining*
305B Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Hartman and Kochanowsky; Associate Professor Stefanko; Assistant Professor Singh.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting), mechanization and mine plant (unit operations, materials handling, continuous mining, power supply), development and exploitation methods (mine planning and layout, design of systems), mine management, production engineering and operations research (time study, standards, job rating, operations analysis), environmental control (gas and dust technology, ventilation, air conditioning, hygiene, illumination, safety), and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation).

A bachelor's degree in mining engineering or some related engineering field is required for admission to graduate work. Students may be required to make up deficiencies in their area of specialization. Certain basic, related courses outside the department may be approved as part of the major.

MINING (MNG)

402. Mine Power (3)
410. Mining Engineering Analysis (3)
411. Mine Systems Engineering (3)
412. Mine Management (2)
422. Mine Ventilation and Air Conditioning (3)
431. Rock Mechanics (3)
451-452. Advanced Mining Engineering I and II (1 each)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

525. Dust Technology (3) Physical and chemical properties of dusts; airborne dust determinations and analysis; dust control applicable to mills and mines. Prerequisite: Mng. 422.

526. Mine Ventilation (3) Airflow in mine openings and its control; network solution by mathematics and computer; design of mine and industrial ventilation systems. Prerequisite: Mng. 422.

532. Rock Mechanics (3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence. Prerequisite: Mng. 431.

541. Theory of Rock Penetration (3) Behavior of rock under dynamic loads intended to penetrate; basic energy relations; application of theory to drilling and other penetration. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Graduate Mining Seminar (1 per term) Preparation and presentation of formal papers on problems of an advanced nature in mining engineering. Required once during each year of residence.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mining studies are listed under Mineral Sciences.*

MUSIC

Hummel Fishburn, *Head of the Department*
232 Arts Building I

Degree Conferred: M.A.
Graduate Faculty: Professors Fishburn, Henninger, Stevens, and Taylor; Associate Professors Karhan and Raver; Assistant Professor Brinsmaid.

In his graduate program a student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, music literature, and creative music.

Admission requires completion of a recognized music major. A thesis is required of all M.A. candidates in this major.

MUSIC (MUSIC)

407. Piano Literature (3)
410. Music of the 20th Century (3)
411. A Chronological Study of String Literature (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
*429. Singer's Style and Interpretation (3) Fee $80.
456. Elementary Counterpoint (3)
459. Modern Instrumental Arranging (3)
466. Advanced Conducting (3)

*503. Advanced Stringed Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on 20th century practices with attention to traditional idioms that serve as foundation.

557. Symphonic Structure (3) Survey of the evolution and application of the forms used in symphony, sonata, concerto, string quartet, and related works. Prerequisite: Music 57.

*558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms. Prerequisite: 18 credits in harmony, counterpoint, and piano.

563. Free Arranging (3) Correct procedure in arranging for vocal and instrumental ensembles; practical exercises in quartets, glee clubs, and choruses; small instrumental groups, band, and orchestra. Prerequisite: 18 credits in harmony, including 3 of orchestration.

567. The Literature of the Orchestra (3) The suite, symphony, tone poem, and overture from the point of view of appreciation, form, and orchestration. Prerequisites: Music 6 and theoretical knowledge of the key instruments of the orchestra.

599. Music Seminar (1-3) Seminar in the history, art, and science of music, with readings, discussion, and performance.

MUSIC EDUCATION

Hummel Fishburn, *Head of the Department*
264 Chambers Building

Degrees Conferred: D.Ed., M.Ed.
Graduate Faculty: Professors Andrews, Dunlop, and Fishburn; Associate Professors Campbell and Karhan.

*May be repeated for a total of 12 credits.

A student majoring in music education is required to offer a minor in music. However, the master's program must include some work, and the doctoral program considerable work, in the area of general education.

Doctoral students may specialize in vocal, instrumental, or theoretical music in elementary, secondary, or college teaching; but the degree requires work in each of these fields.

For admission to a graduate program a student must have completed a recognized music education major.

MUSIC EDUCATION (MU ED)

446. The Elementary Music Specialist (3)
462. Pedagogy of Theory (3)
468. The Teaching of Piano (3)
469. Band and Orchestra Technique (3)
470. Choral Technique (3)
475. Objectives and Problems in Elementary Music Education (3)
480. Choral Program in the Secondary School (3)
*487. Children's Songs and Records (3)

500. Music Education Seminar (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

569. Present-Day Trends in Instrumental Music (3) New methods and materials for band, orchestra, and ensembles.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

594. Pedagogy of Ear Training (3) Materials and methods for training the listener to grasp, understand, and write what is heard from melody to four-part harmony. Prerequisite: 12 credits in ear training and/or harmony.

NUCLEAR ENGINEERING

Nunzio J. Palladino, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Professors Foderaro and Palladino; Associate Professors Diethorn, Jacobs, Kline, and Remick.

*Credit not allowed for students majoring in music or music education.

A student may specialize in reactor physics, neutron and radiation transport phenomena, thermal and mechanical design of reactors, supervision and utilization of research reactors, nuclear materials, or reactor instrumentation and control. Admission requires a bachelor's degree in engineering or in the physical sciences. Students who have not had appropriate undergraduate courses in modern physics and differential equations will be required to schedule them.

NUCLEAR ENGINEERING (NUC E)

410. Nuclear Engineering (3)
411. Nuclear Engineering (3)
420. Radiological Safety (2)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 521.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 521.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 100.

507. Interaction of Radiations with Matter (2) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisites: Phys. 406; 454 or 456.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521. Neutron Transport Theory (3) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

550. Special Topics in Nuclear Engineering (1-12) Theoretical studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 44, Phys. 406.

PHYSICAL SCIENCE (PH SC)

501. Seminar in Nuclear Science and Engineering (0)

PETROLEUM AND NATURAL GAS ENGINEERING

C. Drew Stahl
Head of the Department of Petroleum and Natural Gas
26 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Nielsen, Slobod, and Stahl; Associate Professors Bissey and Burcik.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

Students who expect to enter graduate study in this field with a degree in another major should present 20 credits in chemistry and physics, 6 in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission.

Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

PETROLEUM AND NATURAL GAS (P N G)

410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
431. Drilling Fluids (2)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)

510. Flow of Homogeneous Fluids Through Porous Media (3) Concepts and mathematics describing steady and unsteady state flow in porous media for various initial and boundary conditions.

*512. Reservoir Engineering (3-6) Applications of the principles of fluid behavior in porous media to the analysis of complex reservoir behavior; log interpretation. Prerequisite: P.N.G. 510.

515. Secondary Recovery (3) Methods of predicting oil recovery by immiscible fluid injection.

517. Case Studies of Secondary Recovery (1-3) Interpretation and critical analysis of production and injection characteristics of typical water flood operations. Prerequisite: P.N.G. 515 or 485.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

525. Special Topics in Petroleum Engineering (2-6)

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycles; current developments. Prerequisite: P.N.G. 481.

*Credits to be arranged, 3 per term.

†535. Seminar (1-3)

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Mineral Sciences.*

PHILOSOPHY

John M. Anderson, *Head of the Department*
420 Boucke Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Anderson, Bugbee, Finch, Freund, Johnstone, and Mourant; Associate Professors Rosen and Tsugawa; Assistant Professors Gotshalk, Price, and Whittier.

A student may concentrate on history of philosophy, logic and scientific methods, or value theory. The department may waive the requirement of a thesis for M.A. candidates in this major.

Undergraduate preparation should include a major in philosophy, but a strong minor may also be acceptable.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
410. Studies in Greek Philosophy (3-6)
411. Studies in Modern Philosophy (3-6)
412. Studies in Contemporary Philosophy (3)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)
417. Nineteenth Century Philosophy (3)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Classics of Scientific Method (3)
426. Metaphysics (3)
427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (3-6)
435. Religion and Science (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

507. Seminar in Medieval Philosophy (3-6) Study of one or more important men or movements in medieval philosophy.

†Credits to be arranged, 1 per term.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the 19th century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in 20th century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in 19th Century Philosophy (3-6) Study of a philosopher or philosophical movement of the 19th century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (3-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550-551. (Math. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. (Math.) 428.

554. (Math. 554) Metamathematics (3) Prooftheoretic and modeltheoretic study of systems: Gödel's theorem, relative and absolute consistency proofs, decidability, properties of relational structures, mathematical applications. Prerequisite: Phil. (Math.) 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; recursive and recursively enumerable sets; equivalent formulations of computability; Church's thesis; related topics from current literature. Prerequisite: Phil. (Math.) 428.

PHYSICAL EDUCATION

Benjamin H. Massey
Associate Dean of the College of Health and Physical Education
246 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Buskirk, Conger, Coombs, Gross, Harnett, Lawther, Massey, and Thiel; Associate Professors Lucey, Magnusson, and Nelson.

Emphasis may be placed on health education, physical education, or recreation education.

In health and physical education, areas of specialization include: (1) history, philosophy, and principles; (2) applied science (physiology of exercise, kinesiology, body mechanics); (3) organization and administration; (4) objectives, programs, methods, and evaluation; (5) adaptives and correctives; (6) health content; and (7) athletics, intramural and interschool. The master's candidate is expected to acquire a basic minimum of knowledge in each of these areas with little specialization except

for his thesis or problem. The doctoral candidate is expected to focus on one area during his final year of graduate work.

The requirements for admission to the M.Ed. program are 24 credits in professional health and physical education and 24 in education and psychology, including general psychology, educational psychology, principles and methods of teaching, education electives, and practice teaching.

The requirements for admission to the M.S. program are 36 credits in professional health and physical education and 18 in education and psychology. An excellent background in the biological and physical sciences may satisfy up to half of the requirement in professional health and physical education. Biological science majors, with appropriate course selection, may qualify for the health education option.

In the recreation option, students may prepare for park and recreation administrative positions in municipal, state, or federal agencies; semipublic or private agencies; hospitals or industries; or for leadership of special groups in a particular activity. The areas for specialization include: (1) history, philosophy, and principles; (2) administration and supervision; (3) planning park areas and facilities; (4) program content and application; (5) surveys and appraisals; (6) public administration; and (7) research.

To qualify for the recreation option, an undergraduate major in recreation education is desirable; but a major in sociology, music, physical education, fine or industrial arts, theatre arts, or other related fields may be accepted.

Students who lack some of the prerequisite courses may be admitted but are required to make up the deficiency without degree credit.

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)

501. Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

PHYSICAL EDUCATION (PH ED)

452. Analysis of Physical Education Activities for the Elementary School (3)
454. The Natural Program of Physical Education Activities, Applied (3)
455. Scientific Method in Health and Physical Education (3)
460. Methods and Principles of Athletic Coaching (3)
480. Advanced Anatomy and Physiology, Applied (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)

500. Problem in Physical Education (3) Prerequisite: Ph.Ed. 455.

522. Organization and Administration of Physical Education in Colleges and Universities (3) Administration of physical education in college; credits, schedules, excuses, records, reports, budgets, classification, tests, staff, and facilities. Prerequisite: Ph.Ed. 491.

523. Administration of College Athletics (3) Eligibility, schedules, managerial systems, relationships of athletics to the physical education program and to education in general. Prerequisite: Ph.Ed. 491.

530. Research Techniques in Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 490.

531. Research in Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction. Prerequisite: Ph.Ed. 454.

535. Modern Foreign Systems of Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

536. Scientific Methods in Athletic Coaching (3) Unusual techniques in athletic coaching which are not commonly recognized and used; advanced skills and strategy in coaching major sports. Prerequisite: Ph.Ed. 460.

550. Seminar in Health and Physical Education and Recreation Education (1-6)

555. Relationships of Physical Education to the Exact Sciences (3)

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education into the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

581. Problems in Body Mechanics (3) Certain aspects of human motion and body segmental alignment; analysis of human gait, and the dynamic adaptation of the spine, thorax, and pelvis to external physical forces. Prerequisites: Hl.Ed. 244, Ph.Ed. 399.

595. Philosophy of Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 491 or Rc.Ed. 465.

RECREATION EDUCATION (RC ED)

430. Camping and Outdoor Education (3)
434. (L.Arch. 434) Recreation Areas and Facilities (3)
456. Social Recreation (3)
461. Community Recreation (3)
465. Administration of Recreation (3)

530. Camp Administration (3) Camp site development; staff selection, training, and supervision; development of objectives and program planning; values inherent in outdoor and camping education. Prerequisite: Rc.Ed. 430.

560. Administrative Problems of Recreation (3) Administrative problems in park and recreation departments; departmental organization, finance, personnel, facilities, program, and public relations. Prerequisite: Rc.Ed. 465.

PHYSICAL SCIENCE

HENRY W. KNERR
Chairman of the Committee on Physical Science
101 Willard Building

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, includes at least 24 credits in physical science chosen from chemistry, earth sciences, mathematics, and physics and a minor of at least 6 credits in educational foundations. A candidate is required to earn at least 15 credits in chemistry and physics with a minimum of 6 in each, and at least 3 credits each in earth sciences and mathematics. The completion of a satisfactory term paper and a course in integral calculus is also required.

For admission to the M.Ed. program a student is expected to have completed at least one year each in college chemistry and college physics, mathematics through trigonometry, and 18 credits in education and related psychology. For admission to the D.Ed. program a course in integral calculus is also required.

The D.Ed. program requires a minimum of 60 credits in physical science of which 24 may be in courses designed specifically for teachers. At least 12 credits each in chemistry and physics must be selected from standard courses at the 400 and 500 level. A minimum of 15 credits each is required in professional education and thesis research. The thesis may be based on an experimental study in chemistry or physics or on the study of a problem in the teaching of physical science.

See also "Earth Sciences," "Chemistry," "Mathematics," and "Physics."

PHYSICS

DAVID H. RANK, *Head of the Department*
101 Osmond Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Professors Bleuler, Brickwedde, Frankl, Gibbons, Knerr, McCubbin, Müller, Pratt, Rank, Schilling, Webb, and Wiggins; Associate Professors Bauer, Burnett, Cutler, Kazes, Kendall, McKelvey, Strother, Weber, and Work; Assistant Professors McCammon, Thwaites, and Yahia.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, crystal structure, solid state, field emission, acoustics, high-pressure physics, biophysics, plasma physics and shock waves, low-temperature physics, nuclear physics, physics of high polymers, and various phases of theoretical physics.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed 18 credits in college physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including Phys. 400 and 458 and approved laboratory work such as Phys. 470; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education.

PHYSICS (PHYS)

400. INTERMEDIATE ELECTRICITY AND MAGNETISM (4)

402. Electronics (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
411. Theoretical Mechanics (3)
412. Introduction to Solid State Physics (3)
417. The Teaching of Physics (3)
420. Intermediate Heat (3)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
436. Optics for Teachers (3)
437. Heat, Wave Motion, and Sound for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
441. Demonstration Experiments for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)
477. X-ray Analysis of Solids and Liquids (3)

507. Thermodynamics and Kinetic Theory (3) Classical and modern thermodynamics; introduction to statistical mechanics.

509. Physics Seminar (1-3 per term) Topics from current research.

512-513. Solid State Physics (3 each) Analytical treatment of physical properties of solids: crystal structure, X-ray diffraction, lattice vibrations, paramagnetism, ferromagnetism, ferroelectricity; electron theory of metals, semiconductors. Prerequisite: Phys. 530.

517. Statistical Mechanics (3) Classical and quantum statistics, theory of ensembles, degenerate gases, applications to low temperature effects and cooperative phenomena. Prerequisites: Phys. 507, 561.

521. Crystal Structure (3) Crystal symmetry, X-ray scattering, theory and techniques of crystal structure determination.

522. Advanced Crystal Analysis (3) Phase-determining methods in crystal analysis.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle; canonical transformation; Lagrange and Poisson brackets; Hamilton-Jacobi equations; classical theory of fields. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and visco-elastic media. Prerequisite: Phys. 530.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's

equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

560. Research Problems (1-10) Introduction to research through individual assignments.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

575. Special Topics (1-3 per term) Theoretical studies in any field of modern physics with or without associated experimental work. Prerequisite: Phys. 456.

PLANT PATHOLOGY

James Tammen, *Acting Head of the Department*
111 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Boyle, Graham, Kneebone, Lewis, Mills, and Wernham; Associate Professors Bloom, Couch, and Tammen; Assistant Professor Wood.

A student may specialize in the study of plant diseases caused by fungi, bacteria, or viruses, and/or in their control, especially by plant breeding or by chemical means.

For admission a student must present at least 27 credits in botany, plant pathology, and biological science, of which not more than 6 may be in biological science. As many as 6 credits may be made up as undergraduate deficiencies after the candidate has been admitted to the Graduate School.

See also "Botany" and "Genetics."

PLANT PATHOLOGY (P PATH)

408.	Plant Pathological Techniques (3)	*Mr. Bloom*
410.	Intermediate Plant Pathology (1)	*Mr. Wood*
411.	Diseases of Ornamental and Floricultural Plants (2)	*Mr. Tammen*
412.	Advanced Forest Pathology (2)	*Mr. Wood*
413.	Diseases of Field Crops (2)	*Mr. Couch*
414.	Diseases of Fruit and Vegetable Crops (2)	*Messrs. Bloom and Boyle*
429.	Phytonematology (3)	*Mr. Bloom*

501. Clinical Plant Pathology (3) Advanced course in diagnostic techniques to acquaint the students with specialized procedures for field and laboratory identification of plant diseases. Prerequisites: P.Path. 10, 408, Bot. 419. Summer term, odd years. *Mr. Couch*

510. Advanced Plant Pathology (3) Principles of plant disease development; emphasis on physiology of suscept-pathogen interactions and on development of epiphytotics. Prerequisites: P.Path. 410, Bot. 419. Winter term, odd years.
Mr. Tammen

515. Disease Resistance in Plants (2-4) Stability of resistance, selection of resistant material, economics of control, special problems. Prerequisites: Bot. (Zool.) 22 or 33, P.Path. 10. Fall term, odd years. *Mr. Wernham*

518. Special Problems (1-12) The prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Virus Diseases of Plants (3) Nature, symptomatology, transmission, and control of virus diseases of plants. Fall term, even years. *Mr. Boyle*

520. Plant Pathogenic Bacteria (3) Bacteria causing plant diseases; methods of identification, inoculation, and control. Spring term, odd years. *Mr. Kneebone*

530. Plant Disease Control (3) Methods, and laboratory and field testing of materials used in plant disease control. Spring term, even years.

531. Plant Pathology Seminar (1 per term) Selected topics of current research, history, and contemporary trends in plant pathology.

POLITICAL SCIENCE

John H. Ferguson, *Head of the Department*
129 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Aspaturian, Atwater, Brewster, Ferguson, Masters, McGeary, and Silva; Associate Professors Monat and Thurber; Assistant Professor Albinski.

Students may specialize in American government, public administration, political theory, international relations, or comparative government.

Applicants for admission will be expected to have at least 12 credits in political science or its equivalent. In exceptional cases students may be permitted to make up deficiencies after beginning their graduate programs.

The department may waive the requirement of a thesis for M.A. candidates in this major.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Messrs. Masters and Pettit*
411. American Political Theory (3)
413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian and Atwater*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*
415. International Organization (3-6) *Messrs. Aspaturian and Atwater*
416. International Law (3) *Messrs. Aspaturian and Jordan*
417. American Local Government and Administration (3) *Mr. LeDuc*
419. Public Administration (3) *Mr. Monat*
421. Modern Political Theory (3)
426. Political Parties (3) *Miss Silva*
427. Political Opinion and Propaganda (3) *Miss Silva and Mr. Pettit*
431. Ancient and Medieval Political Theories (3)
432. Current Political Trends and Problems in the United States (3-9)
433. The Law of Labor-Management Relations (3) *Mr. Brewster*
442. American Foreign Policy (3) *Mr. Atwater*
444. Government Regulation (3)
445. Administrative Law (3) *Mr. Brewster*
447. Constitutional Law: The Federal System (3) *Miss Silva*
448. Constitutional Law: Government and the Individual (3) *Mr. Brewster*

450. Governments and Foreign Policies of the Commonwealth of Nations (3) *Mr. Albinski*

451. Comparative Political Systems (3) *Mr. Albinski*

456. Governments and Foreign Policies of Latin America (3) *Mr. Jordan*

458. Governments and Foreign Policies of the Far East (3-6) *Mr. Kochanek*

499. Foriegn Study in Government (2-6)

500. Seminar in Political Science (3-12) Subject to be announced.

505. Seminar in Advanced American Government (3-12) *Miss Silva, Messrs. Ferguson and Monat*

509. Research Techniques in Political Science (3)

512. Comparative Government (3-12)

515. International Relations (3-6)

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

519. Public Administration (3-6)

521. Political Theory (3-6)

535. Government Regulation (3-6)

570. Current Trends and Problems in Administration (3-6) *Mr. Ferguson*

571. Theory of Public Management (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Monat*

572. International Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. Thurber*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. Thurber*

575. Public Personnel Administration (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline.

576. Public Fiscal Administration (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *Mr. Monat*

577. Public Organization and Methods (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy.

578. Public Planning and Zoning (3) Public planning agencies and their functions; essentials of effective planning and zoning; current trends and problems.

580. Internship in Public Administration (6)

POULTRY SCIENCE

Arthur J. G. Maw, *Head of the Department*
103 Weaver Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Bressler, Hale, Maw, Mueller, and Murphy; Associate Professors Buss and Schein.

Students may specialize in poultry nutrition, poultry management, poultry products, poultry breeding, or animal behavior. In each area the program consists of a joint major between the Department of Poultry Science and one or more basic science departments. Admission requirements vary according to the area of specialization. Students with undergraduate majors in the basic sciences may qualify.

Excellent facilities are available for research in production, processing, and preservation of market eggs and dressed poultry, and in chick and poult nutrition. A specially designed and equipped Solar Laying House also provides facilities for investigation of production and behavioral problems encountered in large, concentrated populations of layers.

POULTRY SCIENCE (PTY SC)

401. (Psy. 401, Zool. 401) Animal Behavior (3) *Mr. Hale*
402. Special Topics (3-12)

502. Advanced Poultry Nutrition (2-4) *Mr. Murphy*

503. Advanced Poultry Farm Management (2-4) *Mr. Bressler*

504. Advanced Market Poultry and Eggs (2-4) Prerequisites: Pty.Sc. 1, 7; Ag.Ec. 33 or 2 additional credits in poultry science. *Mr. Mueller*

505. Research in Poultry Science (1-10 per term) Prerequisite: 9 credits in poultry science.

506. Seminar in Poultry Science (1-6)

582. (Psy. 582, Zool. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale and Schein*

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

PSYCHOLOGY

Dale B. Harris, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.S.

Graduate Faculty: Professors Adams, Bernreuter, Carpenter, Cofer, Hale, Guest, Guthrie, Hall, Harris, Leibowitz, Lepley, Lundy, Mitzel, Smith, VanOrmer, and Warren; Associate Professors Gorlow, Hoffman, Palermo, Piers, Prokasy, Schipper, Thevaos, and Whaley; Assistant Professor Singer.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, measurement and statistics, social and personality, developmental, clinical, school, industrial and business, engineering and human factors.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computer Center, the Laboratory for Physiological and Comparative Psychology, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a junior-senior scholastic average of B, a minimum of 12 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test. Applicants with a master's degree will have their admission evaluated with emphasis on the quality of their graduate program.

PSYCHOLOGY (PSY)

401. (Pty.Sc. 401, Zool. 401) Animal Behavior (3) *Mr. Hale*
402. Sensation and Perception (3) *Mr. Freeman*
403. Introductory Physiological Psychology (3) *Mr. Warren*
404. Learning and Motivation (3) *Mr. Hall*
405. The Experimental Psychology of Visual Perception (3) *Mr. Leibowitz*
406. Experimental Social Psychology (3)
410. History of Psychology (3) *Mr. Leibowitz*
412. Abnormal Psychology (3) *Mr. Guthrie*
415. Intermediate Statistics in Psychology and Education (3) *Mr. Prokasy*
417. Social Psychology (2-3) *Mr. Singer*
418. Measurement of Personality (3)
419. Guidance and Education in Sexual and Marital Adjustment (3) *Mr. Adams*
422. Psychological Methods of Measuring the Reactions of the Public (3) *Mr. Guest*
425. Psychology of the Elementary School Child (2-3) *Mr. Whaley*
426. Adolescence (2-3) *Mr. Harris*
427. Psychological Principles in Advertising (3) *Mr. Guest*
428. Opinion Research Laboratory (3) *Mr. Guest*
430. Verbal Behavior and Verbal Learning (3)
431. Industrial Psychology (3) *Mr. Smith*
432. Introductory Engineering Psychology (3) *Mr. Schipper*
433. Psychology of Occupational Behavior (2)
436. Mental Hygiene in Schools (3)
437. Psychology of Adjustment (3) *Mr. Gorlow*
438. Theory of Personality (3) *Mr. Guthrie*
440. Psychology Projects (1-6)
441. Industial Motivation and Morale (3)
445. (C.D.F.R. 445) Developement Throughout Adulthood (3) *Mr. Britton*
474. Psychology of Exceptional Children (3) *Miss Piers*
482. Introduction to Clinical Psychology (3) *Mr. Lundy*

500. Seminar: Introduction to Graduate Study (0) For all new graduate students in psychology.

501. Advanced Psychology (3) Comprehensive study of general psychology. Prerequisite: 9 credits in psychology. *Mr. Lepley*

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology. *Mr. Warren*

504. Comparative Psychology (2-4) Behavior from standpoint of phylogenetic growth and development; biological implications; comparison of different types of animals, including man. Prerequisite: 9 credits in psychology. *Mr. Warren*

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Advanced Theory of Learning and Habit Formation (2-3) Critical evaluation of major theories of learning: Hull, Guthrie, Tolman, Lewin; application

of learning theory to major problems in psychology. Prerequisite: Psy. 404 or Ed.Psy. 414.

511. Seminar in Contemporary American Psychology (2-3) Current systems or schools of psychology with comparative study and critical analysis; points of view as presented by recognized leaders. Prerequisite: 9 credits in psychology.

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Theories of Decision-Making (3) Theoretical models and experimental evidence concerning choice behavior, strategies, and values, under riskless conditions and under uncertainty and risk.

517. Psychology of Attitudes and Opinions (3) Acquisition and control of attitudes and opinions, including beliefs, convictions, biases, prejudices, and ideologies as determinants of action. Prerequisite: 18 credits in psychology, including Psy. 417, 422, 437.

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

522. Survey Research Techniques (3) Sample and questionnaire designs for investigation of consumer reactions and social issues, and appropriate analytic procedures. Prerequisite: 3 credits in statistics. *Mr. Guest*

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

528. Opinion Research Administration (3-6) Practicum in planning, development of techniques, and administration of the sample survey. Prerequisites: Psy. 15, 21, 422. *Mr. Guest*

529. (C.D.F.R. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisite: 6 credits in child development or 6 in educational or child psychology, plus 3 in statistics.

534. Advanced Engineering Psychology (3) Experimental studies of psychological factors affecting design and operation of machines. Prerequisites: Psy. 402, 404; or Psy. 432 or 501.

535. Human Development (2-3) Psychological phases of human development throughout the life span; implications for school, community, and home. Prerequisite: 9 credits in psychology.

536. (C.D.F.R. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

537. Seminar in Industrial Psychology (3) Prerequisite: Psy. 431. *Mr. Smith*

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 414. *Mr. Smith*

539. Motivation and Emotion (3) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives. Prerequisite: Psy. 503. *Mr. Hall*

540. Seminar in Clinical Problems (1-6) Contemporary psychological theory, re-

search, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality and relevant research with emphasis upon normal processes. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisites: Psy. 412, 541.

543. Survey of Counseling and Psychotherapy (3) Critical analysis of important systems of counseling and psychotherapy; history, rationale, and method. Prerequisite: Psy. 541.

549. (C.D.F.R. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

551. Theory and Practicum in Clinical Appraisal of Abilities and Intelligence I (3-4) Theories of intellectual behavior; introduction of clinical testing with emphasis on individual intelligence tests. Prerequisites: Ed.Psy. 450, Psy. 482; or 15 credits in psychology. *Miss Piers*

555. Theory and Practicum in Clinical Assessment of Personality (3) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of projective methods. Prerequisite: Psy. 542.

556. Theory and Practicum in Clinical Assessment of Pathological Syndromes (3) Current research and theoretical issues in the clinical assessment of pathological syndromes; includes practicum. Prerequisite: Psy. 555. *Mr. Guthrie*

557. Advanced Personality Assessment (3) Personality and measurement theories related to problems of prediction, diagnosis, and research. Prerequisite: Psy. 556.

560. Practicum in Clinical Methods (3-6) Personality and vocational diagnostic evaluations and short-term counseling with adults and children. Prerequisites: Psy. 482, 541, 551.

561. Clinical Practicum with Children (1-3) Diagnosis and counseling of child-parent problems of learning and adjustment; includes principles of school psychology. Prerequisite: Psy. 560. *Miss Piers*

564. Theory and Practicum in Counseling and Psychotherapy with Adults (3-6) Counseling with personal adjustment problems referred to the Psychology Clinic. Prerequisites: Psy. 543, 560. *Mr. Lundy*

567. Theory and Practicum in Counseling and Psychotherapy with Children (1-3) Practical experience in the Psychology Clinic in use of play therapy with young children; staff meetings; seminar on principles and techniques. Prerequisites: Psy. 543, 560, 564. *Miss Piers*

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-6) Practical experience in the Psychology Clinic in advanced nondirective therapy techniques; staff meetings; case conferences. Prerequisite: Psy. 564.

571. Social Psychology (3) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research. Prerequisite: 3 credits in social psychology.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Pty.Sc. 582, Zool. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.
Messrs. Hale, Schein, and Warren

590. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION

John H. Ferguson
Head of the Department of Political Science
129 Sparks Building

Degree Conferred: M.P.A.
Graduate Faculty: Professors Brewster, Ferguson, and Silva; Associate Professors Monat and Thurber.

All candidates take a core program and may concentrate through electives in one of the following areas: general public administration, municipal management and public planning, or international development administration.
Candidates must present for admission, or make up without graduate credit, at least 6 credits in political science and at least 3 credits in each of the following fields: economics, public finance, accounting or statistics, and psychology.

RURAL SOCIOLOGY

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Bonser, Brown, and John; Associate Professors Bylund, Copp, and Fliegel; Assistant Professor Bealer.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at this University during the early part of his master's program.

RURAL SOCIOLOGY (R SOC)

402. Consumer Behavior and the Agricultural Industry (3) *Mr. Bylund*
444. Rural Life in an Industrial Society (3)
452. Rural Organization (3) *Mr. Copp*
459. Rural Social Psychology (3)

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology. *Mr. Bealer*

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems. *Mr. Bealer*

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452. *Mr. Copp*

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior. *Mr. Bylund*

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system with emphasis on techniques of organization and program development. *Mr. Brown*

516. Change in Rural Society (2) Social change in rural society emphasizing prediction and control of the change process. *Mr. Fliegel*

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING

Benjamin A. Whisler
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.
Graduate Faculty: Professors Kountz and Whisler; Associate Professor Nesbitt.

The entering student should be a graduate in sanitary engineering from an accredited college of engineering, but a graduate in civil engineering may obtain the M.S. in sanitary engineering by taking a limited amount of extra undergraduate work in subjects appropriate to the sanitary engineering field. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 471, 472, 571, 572, 573, 574, 575, 576, 577, and 578. Appropriate courses offered by other departments include: Ag. 400; Bioch. 425, 436; Chem. 405; Cmp.Sc. 402; Geol. 452; Meteo. 445; Micrb. 401, 414; Nuc.E. 420; Pl.Sc. 419; and Zool. 410.

SECONDARY EDUCATION

John Withall, *Head of the Department*
168 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Fowler, McGarey, Patrick, and Remaley; Associate Professors Fagan and Kozak.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the

requirements, including residence, described in the earlier sections of this bulletin. For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the head of the Department of Secondary Education. When course work has been completed more than five years prior to admission to the D.Ed. or when it is transferred from another institution, the head of the department will determine its suitability for any part or all of the 15 hours required.

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the head of the Department of Secondary Education. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or chemistry. These programs require 6 credits in professional education approved in advance by the head of the department responsible for the minor field chosen; e.g., secondary education, agricultural education, etc.

SECONDARY EDUCATION (SEC ED)

400. Modern Trends in the Direction of Learning Experiences (3)
426. Teaching Mathematics in the Secondary Schools (4)
433. Teaching Social Studies in the Secondary Schools (4)
436. Teaching of Conservation of Natural Resources in the Secondary School (3)
437. Teaching of Conservation of Natural Resources in the Secondary School (3)
438. Teaching Science in the Secondary Schools (4)
443. Reading Problems in the Secondary School (2-3)
445. (El.Ed. 445) Techniques in Remedial Reading (2-6)
451. Secondary Education in America (3)
453. Teaching English in the Secondary Schools (4)
454. Extracurricular Activities in the Junior and Senior High School (2-3)
472. Measurement of Achievement in the Secondary School (2-3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 490, and teaching experience.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Bot. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec.Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. (El.Ed. 546) Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (1-4) Historical, psychological, social, and economic factors influencing secondary education; required as basic course of all graduate students in secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

556. (El.Ed. 556) Reading Clinic Practice: Analysis of Reading Disabilities (3-6) Analysis of extreme reading disabilities and recommended procedures; experience in preparation of case reports. Prerequisite: Sec.Ed. (El.Ed.) 445 or El.Ed. 444.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

SLAVIC LANGUAGES AND LITERATURES

Thomas F. Magner, *Head of the Department of Slavic Languages*
120 Sparks Building

Degree Conferred: M.A.
Graduate Faculty: Professor Magner; Assistant Professor Birkenmayer.

Programs leading to the master's degree in this field offer opportunities for specialization in literature or linguistics. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.

A thesis is required of all M.A. candidates in this major.

RUSSIAN (RUS)

426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)
450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)

*1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

501. Readings in Russian Literature (3-6) Prerequisite: Rus. 204.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. Russian Literature to Pushkin (3) Russian literary monuments in the original, 1100-1800.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticsm.

SLAVIC (SLAV)

500. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literature.

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

SOCIAL STUDIES

Hugo A. Meier
Chairman of the Committee on Social Studies
112 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

*No graduate credit is given for this course.

SOCIOLOGY

PAUL T. BAKER
Acting Head of the Department of Sociology and Anthropology
239 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Baker, Clark, Foreman, Mather, and M. B. Matson; Associate Professors Dansereau and Theodorson; Assistant Professors DeJong and Westby.

Undergraduate preparation must include 12 credits in sociology and at least 7 in other social sciences. Students of exceptional ability who are deficient in undergraduate preparation may be accepted provided they make up their course deficiency without graduate credit.

A thesis is required of all M.A. candidates in this major.

SOCIOLOGY (SOC)

400. ADVANCED GENERAL SOCIOLOGY (3)
401. SOCIAL INSTITUTIONS (3)
403. ADVANCED SOCIAL PSYCHOLOGY (3)
408. SOCIAL ECOLOGY (3)
413. METHODS AND TECHNIQUES OF SOCIAL RESEARCH (1-6)
418. THE DEVELOPMENT OF SOCIAL THOUGHT (3)
422. HISTORY OF SOCIOLOGICAL THEORY (3)
423. POPULATION RESEARCH (3)
424. SOCIAL CHANGE (3)
426. PUBLIC WELFARE POLICY AND SERVICES (3)
427. SOCIAL CASE WORK (3)
428. SEMINAR IN SOCIOLOGY (1-6)
429. SOCIAL STRATIFICATION (3)
444. COMPLEX ORGANIZATIONS (3)
446. POLITICAL SOCIOLOGY (3)
450. COMMUNITY ORGANIZATION (3)
454. INDUSTRY AND THE COMMUNITY (3)
455. OCCUPATIONS AND PROFESSIONS (3)
456. READINGS IN SOCIOLOGY (1-9)
457. FIELD WORK IN INDUSTRIAL SOCIOLOGY (1-6)
470. INTERMEDIATE SOCIAL STATISTICS (4)
499. FOREIGN STUDY IN SOCIOLOGY (2-6)

500. SEMINAR IN GROUP THEORY (1-3) The group as a unit of social structure and action.

502. THEORIES OF SOCIETY (3) Past and present theories of the overall structure and processes of societal functioning.

503. RESEARCH SEMINAR IN SOCIAL PSYCHOLOGY (3-6) Design and conduct of research in areas of mutual interest in social psychology.

505. CURRENT SOCIAL THEORY (3) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. SEMINAR IN SOCIOLOGICAL THEORY (3-9)

510. FIELD WORK IN SOCIOLOGY (1-6)

513. Seminar in Sociological Research Problems: A. Research Techniques; B. Current Research (3-6) Prerequisite: 3 credits in statistics.

515. Seminar in Community Studies (3)

523. Population Problems (1-6)

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572. Methods of Sampling (3) Application of sampling techniques to sociological research.

SOLID STATE TECHNOLOGY

Rustum Roy
Chairman of the Committee on Solid State Technology
121 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

The aim of this program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The subject matter, taught by various departments, is grouped into four areas: (1) the structure of solids, (2) theory related to the solid state, (3) properties of solids, and (4) reactions of solids.

Course work should be so distributed that one area is encompassed in depth while a substantial number of credits is chosen from any combination of the other areas. Thesis research on various aspects of the solid state may be conducted in appropriate departments in the Colleges of Engineering, Mineral Industries, and Science; and in the Materials Research Laboratory.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. They should be specifically interested in an interdisciplinary program of study and research.

SPANISH

Anthony M. Pasquariello
Head of the Department of Spanish, Italian, and Portuguese
212 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Professors Bleznick, Moser, Pasquariello, and Sturcken; Associate Professor Brentin; Assistant Professors Dalbor and Triolo.

The minimum requirement for admission to an advanced degree program will normally be 24 credits of post-intermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

SPANISH (SPAN)

400. Advanced Composition and Conversation (3)
404. The Evolution of Spanish (3)
413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)
*450. Spanish Institute (7-14)
452. Spanish Literature in the Romantic Period (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
482. Spanish Lyric Poetry (3)
483. Spanish Drama of the 19th Century (3)
484. Contemporary Spanish Drama (3)
487. The Spanish Novel of the 19th Century (3)
488. The Contemporary Spanish Novel (3)
498. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation.

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials.

505. Old Spanish: Phonology, Morphology, and Syntax (3)

506. History of the Spanish Language (3)

510. Spanish Descriptive Linguistics: Phonology (3)

511. Spanish Descriptive Linguistics: Morphology and Syntax (3)

515. Medieval Spanish Literature (3)

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry.

528. Spanish Renaissance and Golden Age Prose (3) Various types of novels with special emphasis on the picaresque; didactic literature; histories.

535. Renaissance and Golden Age Literature (3-6) Nature and development of Spanish literature of the 16th and 17th centuries; topics will vary.

*A maximum of 7 credits in one summer.

537. Lope de Vega and Calderón (3) Major works of these and other dramatists of the Golden Age.

540. Cervantes and His Works (3)

543. Spanish Literature of the 18th Century (3) Didactic literature, poetry, drama, and novel in the most representative writers in the century.

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós.

559. The Generation of 1898 (3) Principal works and intellectual trends of the period with special emphasis on Unamuno.

564. Twentieth Century Hispanic Literature (3-6) Principal trends and works after the Generation of 1898 and *modernismo;* topics will vary.

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío.

580. History of the Spanish Essay (3) The principal essayists from the 16th century to the present.

585. Hispanic Poetry of the 19th and 20th Centuries (3) Various currents in the poetry of the Iberian peninsula and Latin America.

598. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature.

SPEECH

Robert T. Oliver, *Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Arnold, Nelson, Oliver, Schug, and Zelko; Associate Professors Brubaker, Fife, Holtzman, Phillips, and White; Assistant Professors Brilhart, Dunham, and Olbricht.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

A thesis is required of all M.A. candidates in this major.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Schug*
402. General Semantics (3) *Mr. Brilhart*
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Criticism (3) *Mr. Arnold*
415. Experimental and Applied Phonetics (3) *Mr. Brubaker*
417. Directing Forensics (3) *Mr. Dunham*
425. (Brcst. 425) Radio Programming and Performance (3) *Mr. Nelson*

431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Mr. Brubaker*
435. (Brcst. 435) Radio and Television Programming (3) *Mr. Nelson*
437. (Brcst. 437) Television Programming and Performance (3) *Mr. Hungerford*
450. Discussion: Research and Theory (3) *Mr. Brilhart*
475. Studies in Mass Persuasion in the Democratic Society (3) *Mr. Hager*
476. Oriental Rhetoric and Contemporary Public Address in the Far East (2) *Mr. Oliver*
477. Contemporary Public Address: the Great Dictators (2) *Mr. Oliver*
478. Contemporary Public Address: English and American Speakers (2) *Mr. Oliver*
485. Advanced Oral Interpretation of Literature (3) *Mr. Hamilton*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*
494. Teaching of English as a Second Language (3)
496. Speech for Teachers (3) *Mr. Dunham*

500. Seminar in American Oratory (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Dunham*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech.

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Oliver*

520. Seminar in Speech Science (2-4) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Mr. Brubaker*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Holtzman*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communication skills. *Mr. Zelko*

555. Speech Communication: Problems and Principles (2-4) Prevalent theories of speech influence. *Mr. Oliver*

560. Public Address (2-4) Discussion and criticism of speech outline, manuscript, content, composition, and delivery. Prerequisite: 6 credits in speech including Spch 200. *Mr. Schug*

575. Research Problems in Speech (1-12) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology.

SPEECH PATHOLOGY AND AUDIOLOGY

Bruce M. Siegenthaler
In Charge of Graduate Programs in Speech Pathology and Audiology
2S Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors McDonald and Siegenthaler; Associate Professors Berlin and Frick; Assistant Professor Raabe.

Students may specialize in either speech pathology or audiology. Admission to study for the master's degree requires 27 credits in clinical speech and hearing, education, and psychology, including at last 9 in speech pathology and/or audiology and a course in statistics.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

STATISTICS

James B. Bartoo, *Chairman of the Committee on Statistics*
231 McAllister Building

No advanced degree is offered in this field, but a candidate with a major in another field may choose a minor in statistics upon approval by his major department.

This minor is intended to facilitate development of a coherent program of study in this vital branch of the scientific method. The candidate will be expected to become conversant with the broad field of statistics and to become reasonably proficient in the statistical methods particularly useful in the subject-matter areas of his major field. The member of the candidate's committee representing the minor in statistics will have responsibility for determining course work acceptable in satisfying requirements for the minor.

The minimum requirements for a minor for a master's degree are 3 credits in mathematical statistics and 6 in applied statistics. For a doctor's degree a minimum of 15 credits in statistics is required for a minor, of which at least 6 must be mathematical statistics and at least 6 must be applied statistics.

Courses in mathematical statistics are: Math. 409, 410, 542, and 543.

Courses in applied statistics are: Ag. 400; Ag.Ec. 505, 520; Ag.Ed. 521v; Agro. 512, 545; B.S. 500, 501; Econ. 510; Ed.Psy. 406, 506; For. 450; I.E. 423; Meteo. 450; Min. 513, 514, 526; Psy. 415, 515, 527; and Soc. 470, 572.

THEATRE ARTS

WALTER H. WALTERS, *Head of the Department*
201 Schwab Auditorium

Degrees Conferred: M.A., M.F.A.
Graduate Faculty: Professors Neusbaum, Smith, and Walters; Associate Professors Reifsneider and Yeaton; Assistant Professor Allison.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.

The M.F.A. program is planned to provide a professional emphasis. Students will take a core program and specialize in performance (acting, directing), dramatic writing, or production (scene design, technical direction, stage lighting, stage costuming).

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

Requirements for admission to the M.A. program are a broad undergraduate preparation; one course each in basic acting, directing, theatre crafts, and history of the theatre, or their equivalents; and 12 credits divided among speech, music, art, and dramatic literature, or 9 credits in one of these fields.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, 3 of which must be in history of the theatre. In certain cases courses in speech, dramatic literature, art, music, dance, architecture, and other similar subjects may be accepted.
2. Auditions or submission of manuscripts, portfolios, photographs of theatre work, or other evidence of ability, according to specialization, as arranged by the student with the department.

All students in the M.A. and M.F.A. programs who lack the expected upper-class undergraduate courses in theatre may be requested to take additional course work without degree credit. All graduate majors are required to participate in University Theatre productions in positions of responsibility.

THEATRE ARTS (THEA)

404. STYLES OF ACTING (3-6)
412. ADVANCED SCENE DESIGN (3)
413. STAGE LIGHTING (3)
414. STAGE COSTUMING (3)
415. THEATRE ORGANIZATION AND MANAGEMENT (3)
421. ADVANCED PLAYWRITING (3)
431. HISTORY OF THE THEATRE (3)
433. DANCE FOR THE THEATRE (3)
442. CREATIVE DRAMATICS WITH CHILDREN (3)
443. MARIONETTES AND PUPPETRY (3)
451. DIRECTING (3)
452. CENTRAL STAGING (3)
470. THEATRE PRODUCTION (1-6)
481. (Brcst. 481) TELEVISION DRAMA (3)
482. (Brcst. 482) RADIO AND TELEVISION DIRECTING (3)

501. PROBLEMS OF DIRECTING (3-6) Seminar in problems of production with particular stress on direction. Students will direct plays under staff supervision.

502. Seminar in the Technical Problems of Dramatic Production (3-6) Prerequisite: Thea. 11.

504. Seminar in Styles of Acting (3-6) Practical work required of each student.

506. Evaluation and Appreciation of Modern Dramatic Entertainment (3) Prerequisites: Thea. 1, 61.

507. Seminar in Fundamental Theories of Theatre and Drama (3-6)

521. Playwriting (3-6) Prerequisites: Thea. 21, 421.

VOCATIONAL INDUSTRIAL EDUCATION

George L. Brandon
Head of the Department of Vocational Education
245 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Brandon and Williams; Associate Professor Brantner.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in vocational industrial education is required for admission.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)
403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (4)
415v. Problems in Coordinating Vocational Education (3)
420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. Vocational Education for Administrators (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. Research in Vocational Education (3) Research techniques in vocational industrial education.

558v. Emerging Problems in Industrial and Technical Education (2-3 per unit)

Unit A. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

Unit B. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.

Unit C. State and Local Supervision and Administration (2-3) The more important recent problems in organization, supervision, and administration.

Unit D. Vocational Technical Education (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. PHILOSOPHY OF INDUSTRIAL EDUCATION (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT

BERTIL G. ANDERSON
Head of the Department of Zoology
212 Frear Laboratory

or

ROBERT E. MCDERMOTT
Head of the Department of Forest Management
109 Forestry Building

Degree Conferred: M.S.

Graduate programs in the field of wildlife management are offered by the Department of Zoology for students primarily interested in the animal aspects, and by the Department of Forest Management for those primarily interested in the habitat aspects.

ZOOLOGY

BERTIL G. ANDERSON, *Head of the Department*
212 Frear Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Anderson, Anthony, Cheng, Cooper, Davis, Hale, and Wright; Associate Professors Bellis, Boyle, Grun, Houlihan, Schein, and Wood.

Students may specialize in animal behavior, bioacoustics, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, physiology, population dynamics, or wildlife management.

In order to undertake graduate work in zoology, students are required to have had 24 credits in zoology and related biological sciences; and they should have had chemistry through organic chemistry. Courses in physics and mathematics are also advantageous. A limited deficiency may be made up without degree credit while pursuing graduate work.

ZOOLOGY (ZOOL)

401. (Pty.Sc. 401, Psy. 401) ANIMAL BEHAVIOR (3) *Mr. Hale*
403. (Ent. 403) SYSTEMATICS (3) *Mr. Boyle*

405. (Bot. 405) General Cytology (3) *Mr. Grun*
408. Mammalogy (4) *Mr. Davis*
410. General Limnology (3) *Mr. Cooper*
415. The Literature of Zoology (1) *Mr. Anderson*
416. The Methods of Research in Zoology (2) *Mr. Anderson*
417. Invertebrate Zoology (3)
419. General Animal Ecology (3) *Mr. Bellis*
421. Comparative Anatomy of Vertebrates (4)
422. (Bot. 422) Advanced Genetics (3) *Mr. Wright*
437. Histology (4) *Mr. Anthony*
440. Embryology (4)
444. Zoological Problems (1-6)
448. Ornithology (3) *Mr. Wood*
450. Ichthyology (3) *Mr. Cooper*
461. Animal Parasitology (3) *Mr. Beaudoin*
471. Vertebrate Physiology (3)

505. (Bot. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Zool. (Bot.) 405 or 422. Spring term, odd years. *Mr. Grun*

509. Techniques in Wildlife Management (2) Evaluation of procedures designed to manage populations of game and fish; elements of statistics of birth and mortality rates; census methods. Fall term. *Mr. Davis*

512. Seminar (1) Review of current zoological literature. Required of graduate students majoring in zoology and entomology.

520. Special Topics (1-6)

524. (Bot. 524) Seminar in Genetics (1 per term) *Mr. Wright*

525. History of Biology (3) Historical development of biological knowledge and theories. Fall term.

528. (Bot. 528) Population Genetics (3) Factors affecting gene frequency, genotype frequency, genotype-environmental interaction, and genetic relationship in natural and artificial populations. Winter term, even years.

533. (Bot. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

537. (Bot. 537, Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term.

541. Cellular and Comparative Physiology (3) Basic functions of animal cells and their variations in the animal kingdom.

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term. *Mr. Davis*

551. Fisheries Management (3) Basic principles underlying management of inland waters for fish production. Summer term, even years. *Mr. Cooper*

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals.

582. (PtySc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research

in special areas of animal behavior involving field or laboratory work.
Messrs. Hale, Schein, and Davis

583. General Endocrinology (2) Anatomy and physiology of the organs of internal secretion; role of hormones in metabolism and development. Spring term, odd years. *Mr. Anthony*

587. Biology of Sex (2) Hereditary and embryological aspects, problems in gonadal differentiation, cyclic reproductive phenomena, actions of the hormones. Spring term, even years. *Mr. Anthony*

Other Elective Graduate Courses

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3) *Mr. Hicks*

ASTRONOMY (ASTRO)

430. General Astronomy for Teachers (3)
470. Solar Physics (3)
490-491. Introduction to Astrophysics (3 each)

BROADCASTING (BRCST)

425. (Spch. 425) Radio Programming and Performance (3) *Mr. Nelson*
435. (Spch. 435) Radio and Television Programming (3) *Mr. Nelson*
437. (Spch. 437) Television Programming and Performance (3) *Mr. Hungerford*
481. (Thea. 481) Television Drama (3)
482. (Thea. 482) Radio and Television Directing (3)
492. (Journ. 492) Public Affairs Broadcasting (3)

COMPUTER SCIENCE (CMP SC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
490. Special Topics in Computer Science (1-9)

ENGINEERING (ENGR)

450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

531. Advanced Digital Computer Programming (3) Nonnumerical applications; symbol manipulation, syntactical analysis, and translation of artificial languages; heuristic methods, learning mechanisms, artificial intelligence.

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

GREEK (GREEK)

421. Greek Tragedy (3)
422. Greek Comedy (3)

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

598. Seminar in Italian Literature (3-12) Common and individual research in special problems.

LABOR-MANAGEMENT RELATIONS (L M R)

411. Trade Union Administration (3)
421. Labor Education (3)

LANDSCAPE ARCHITECTURE (L ARCH)

425-426. Landscape Construction Problems (3 each)	*Mr. Burggraf*
427. Landscape Construction Problems (2)	*Mr. Burggraf*
434. (Rc.Ed. 434) Recreation Areas and Facilities (3)	*Mr. Miller*
454-455-456. Landscape Design (3 each)	*Mr. Miller*
460-461-462. Advanced Landscape Design (4 each)	*Mr. Polakowski*
471. Park Design and Administration (2-4)	*Mr. Wilson*
472. Site Planning of Institutional and Public Projects (2)	*Mr. Miller*
473. Site Planning of Institutional and Public Projects (2)	*Mr. Miller*

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects. Prerequisite: L.Arch. 456.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LATIN (LATIN)

428. Lucretius (3)	*Mr. Krauss*
429. Quintilian (3)	*Mr. Prakken*
431. Juvenal (3)	*Mr. Krauss*
436. The Teaching of Latin (3)	*Mr. Krauss*

500. Latin Literature (3) Lectures and collateral readings on the major forms of Latin literature; readings in the original Latin to supplement the lectures. *Mr. Krauss*

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. *Mr. Krauss*

502. Latin Epigraphy (3) Lectures and readings on Roman inscriptions; illustrative exercises. *Mr. Prakken*

503. Latin Paleography (3) The Latin alphabet, writing materials, Roman book and cursive hands; illustrative exercises. *Mr. Prakken*

504. Roman Topography (3) Physical development of the city of Rome, its walls, aqueducts, bridges, streets, forums, public buildings, temples, etc.; building materials and methods of construction. *Mr. Prakken*

510. Latin Seminar (3) *Mr. Krauss*

518. Latin Research (1-3) Prosecution of an assigned problem under the guidance of a member of the department.

LIBERAL ARTS (L A)

500-501. Fundamentals of Linguistics (3 each) Interrelated problems of language discussed from four points of view: modern structural linguistics, historical linguistics, social psychology, and philosophy.

LIBRARY SCIENCE (L SC)

403. Intermediate Dictionary Cataloging and Subject Headings (3)
405. Intermediate Reference Work and Bibliography (3)

MINERAL SCIENCES (MN SC)

411. Instrument Techniques Applied to Mineral Science Problems (1-3)
421. X-ray Diffraction (3)

510. X-ray and Electron Diffraction Analysis as Applied to Minerals and Metals (2-4) Prerequisite: Mn.Sc. 421.

513. Semiconductor Physics (3) Electronic structure of solids; electronic transport phenomena; semiconductor materials; luminescence. Prerequisite: Phys. 400 or E.E. 32. *Mr. Henisch*

520. Electron Microscopy in Mineral Science Research (1-4) Prerequisite: Mn.Sc. 411, Unit B.

540. Solid State Structures and Reactions in Mineral Systems (2-4) Crystal chemical approach to solid state reactions, sintering, melting, hardness, thermal expansion, and behavior of matter under high pressure. *Mr. Weyl*

PORTUGUESE (PORT)

598. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems.

RELIGIOUS STUDIES (RL ST)

402. Contemporary Religious Thought (3)
430. Religion and Morality (3)
440. Problems in Religious Studies (3-6)

VETERINARY SCIENCE (V SC)

400. Veterinary Anatomy and Physiology (3)
401. Infectious Diseases of Domestic Animals (3)

515. (Micrb. 515) VIROLOGY (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

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1966-1967

THE PENNSYLVANIA STATE UNIVERSITY BULLETIN

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE · FEBRUARY 1966

OFFICES OF THE GRADUATE SCHOOL

University Park Campus
101 Willard Building
University Park, Pa., 16802
Telephone: Area Code 814, 865-6323

King of Prussia Graduate Center
Route 23 and Henderson Road
King of Prussia, Pa., 19406
Telephone: Area Code 215, 265-5400

Susquehanna Valley Graduate Center
2980 North Second Street
Harrisburg, Pa., 17110
Telephone: Area Code 717, 233-1001

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1966-1967

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE • FEBRUARY 1966

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*GRADUATE CALENDAR

WINTER TERM 1966

NOVEMBER 1965

6 Saturday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1966

6 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1966

JANUARY 1966

6-8 Thursday to Saturday Noon—Winter Term Registration

6-8 Thursday to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates

10 Monday—Winter Term Classes Begin 8 a.m.

10 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

18 Tuesday—Graduate Faculty Meeting

19 Wednesday—Last Date for Adding Courses to Approved Schedules

26 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

31 Monday—Written Foreign Language Examinations for Advanced Degree Candidates

FEBRUARY

26 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

MARCH

5 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates

5 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

5 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally

12 Saturday a.m.—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

12 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in March

19 Saturday—Winter Term Classes End 9:55 p.m.

21-23 Monday to Wednesday—Final Examinations

26 Saturday—Commencement

SPRING TERM 1966

JANUARY 1966

31 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1966

31 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1966

*This calendar was approved May 10, 1965. It is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

MARCH

31 Thursday Afternoon—Spring Term Registration Begins
31 Thursday—Oral Examinations in Foreign Languages for Advanced Degree Candidates Begin

APRIL

1-2 Friday to Saturday Noon—Spring Term Registration Continues
1-2 Friday to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates Continue
4 Monday—Spring Term Classes Begin 8 a.m.
4 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
13 Wednesday—Last Date for Adding Courses to Approved Schedules
19 Tuesday—Graduate Faculty Meeting
20 Wednesday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
25 Monday—Written Foreign Language Examinations for Advanced Degree Candidates

MAY

21 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
28 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
28 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser
28 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally

JUNE

4 Saturday a.m.—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
4 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in June
11 Saturday—Spring Term Classes End 9:55 p.m.
13-15 Monday to Wednesday—Final Examinations
18 Saturday—Commencement

SUMMER TERM 1966

APRIL 1966

20 Wednesday—Last Date for a Prospective Graduate Student to Apply for Admission to the Summer Term 1966
20 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1966

JUNE

20-21 Monday p.m. and Tuesday—Summer Term Registration
20-21 Monday and Tuesday—Oral Examinations in Foreign Languages for Advanced Degree Candidates
22 Wednesday—Summer Term Classes Begin 8 a.m.
22 Wednesday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

JULY

1 Friday—Last Date for Adding Courses to Approved Schedules

†4 Monday—Independence Day Holiday
8 Friday—Last Date for a September Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
18 Monday—Written Foreign Language Examinations for Advanced Degree Candidates
19 Tuesday—Graduate Faculty Meeting

AUGUST
6 Saturday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee
13 Saturday—Last Date for Final Oral Doctoral Examination for September Graduates
13 Saturday—Last Date for a September Graduate to Deliver Master's Thesis or Paper to Adviser
13 Saturday—Last Date for a September Graduate to Rent Cap, Gown, and Hood Locally
20 Saturday a.m.—Last Date for a September Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
20 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in September
†31 Wednesday—Summer Term Classes End 9:55 p.m.

SEPTEMBER
1-2 Thursday and Friday—Final Examinations
4 Sunday Afternoon—Commencement

FALL TERM 1966

JULY 1966
28 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Fall Term 1966
28 Thursday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1966

SEPTEMBER
28-30 Wednesday p.m. to Friday—Fall Term Registration Begins
28-30 Wednesday p.m. to Friday—Oral Examinations in Foreign Languages for Advanced Degree Candidates Begin

OCTOBER
1 Saturday a.m.—Fall Term Registration Continues
1 Saturday a.m.—Oral Examinations in Foreign Languages for Advanced Degree Candidates Continue
3 Monday—Fall Term Classes Begin 8 a.m.
3 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
12 Wednesday—Last Date for Adding Courses to Approved Schedules
18 Tuesday—Graduate Faculty Meeting
19 Wednesday—Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
24 Monday—Written Foreign Language Examinations for Advanced Degree Candidates

†Classes which would have met on Monday, July 4, will meet according to schedule on Wednesday, August 31, 1966.

NOVEMBER

19 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee

‡24 Thursday—Thanksgiving Day Holiday

26 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates

26 Saturday—Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser

26 Saturday—Last Date for a December Graduate to Rent Cap, Gown, and Hood Locally

DECEMBER

3 Saturday a.m.—Last Date for a December Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

3 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in December

‡12 Monday—Fall Term Classes End 9:55 p.m.

13-15 Tuesday to Thursday—Final Examinations

17 Saturday—Commencement

WINTER TERM 1967

NOVEMBER 1966

5 Saturday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1967

5 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1967

JANUARY 1967

5-7 Thursday Noon to Saturday Noon—Winter Term Registration

5-7 Thursday Noon to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates

9 Monday—Winter Term Classes Begin 8 a.m.

9 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

17 Tuesday—Graduate Faculty Meeting

18 Wednesday—Last Date for Adding Courses to Approved Schedules

25 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

30 Monday—Written Foreign Language Examinations for Advanced Degree Candidates

FEBRUARY

25 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

MARCH

4 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates

4 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

4 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally

‡Classes which would have met on Thursday, November 24, will meet according to schedule on Monday, December 12, 1966.

11 Saturday a.m.—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Required Papers
11 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in March
18 Saturday—Winter Term Classes End 12:25 p.m.
20-22 Monday to Wednesday—Final Examinations
25 Saturday—Commencement

SPRING TERM 1967

JANUARY 1967
30 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1967
30 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1967

MARCH
30-31 Thursday p.m. and Friday—Spring Term Registration Begins
30-31 Thursday p.m. and Friday—Oral Examinations in Foreign Languages for Advanced Degree Candidates Begin

APRIL
1 Saturday a.m.—Spring Term Registration Continues
1 Saturday a.m.—Oral Examinations in Foreign Languages for Advanced Degree Candidates Continue
3 Monday—Spring Term Classes Begin 8 a.m.
3 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
12 Wednesday—Last Date for Adding Courses to Approved Schedules
18 Tuesday—Graduate Faculty Meeting
19 Wednesday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
24 Monday—Written Foreign Language Examinations for Advanced Degree Candidates

MAY
20 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
27 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
27 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser
27 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally

JUNE
3 Saturday a.m.—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
3 Saturday—Last Date for Submitting a Petition to Graduate in Absentia in June
10 Saturday—Spring Term Classes End 12:25 p.m.
12-14 Monday to Wednesday—Final Examinations
17 Saturday—Commencement

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Alfred J. Engel, Ph.D. (Wisconsin)	*Asst. Prof. of Chemical Eng.*
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Hazel M. Hatcher, Ph.D. (Minnesota)	*Prof. of Home Economics Education*
Sabih Hayek, D.Eng.Sc. (Columbia)	*Asst. Professor of Engineering Mechanics*
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Truman V. Hershberger, Ph.D. (Ohio State)	*Assoc. Prof. of Animal Nutrition*
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GENERAL INFORMATION

GRADUATE WORK at The Pennsylvania State University was first offered in 1862 when two graduate students were in residence. It was given more formal recognition in 1864 by the establishment of a "course for Graduates" designed for students who, after receiving the degree of Bachelor of Scientific Agriculture, wished to do advanced work leading to the degree of Master of Scientific Agriculture. For some time there were few graduate students, and graduate instruction was relatively unorganized. Later a committee of the University Senate was given the responsibility of establishing standards and regulations governing graduate work and the granting of advanced degrees. The Graduate School was organized in 1922. Until this time only masters' degrees and certain technical degrees had been conferred. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. Still later other degrees were approved.

The faculty of the Graduate School consists of the President and certain other general administrative officers of the University, the Deans, the Librarian, the heads of departments, and those members of the instructional staff who have been authorized by the proper agencies of the Graduate School to offer graduate courses and supervise research leading to theses. It controls all academic matters pertaining to the Graduate School, subject to review by the University Senate. The Graduate Faculty has approximately 850 members.

During the academic year 1964-65, 3,100 to 3,500 graduate students were enrolled each term. In this interval 1,054 advanced degrees were conferred, of which 232 were doctorates.

GRADUATE CENTERS—University Graduate Centers have been established in the Philadelphia and Harrisburg areas, and others are in the planning stage. Each of the two established centers operates under the immediate direction of a resident assistant dean of the Graduate School and is expected to have full-time resident faculty members in addition to part-time staff as quickly as justified by the enrollment. The programs to be offered in a Center will depend upon its location, the degree of interest, and the availability of qualified students in the immediate area.

The King of Prussia Graduate Center near Philadelphia, which opened in 1963, currently has an enrollment of more than 250 students. Its program leads to the degree of Master of Engineering with a major in Engineering Science.

The Susquehanna Valley Graduate Center in Harrisburg opened in 1965 with an enrollment of 55. The only program currently available leads to the degree of Master of Engineering in Engineering Science. Other programs are planned for the near future.

Interested students are urged to write directly to the dean at the Center for information on programs and courses. Addresses are given on the inside of the front cover of this bulletin.

NEW MEDICAL CENTER—A gift of $50,000,000 from the Milton S. Hershey Foundation has made possible the establishment of a medical center near Harrisburg, Pennsylvania, for which plans are now being formulated. The program will emphasize medical research and operate in close cooperation with related departments on the University Park Campus.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at Penn State by scheduling relevant courses and research at University Park. Similarly a graduate student with an appropriate major at Penn State may earn credits at Jefferson which, upon advance approval by his major department, will be accepted in partial fulfillment of degree requirements at Penn State.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in this publication, the *Manual for Graduate Students,* and the *Thesis Information Bulletin,* and for meeting the standards and requirements expressed by these regulations. The *Manual,* which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Dean's office soon after admission.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not simply an extension of undergraduate work. It operates at a definitely higher level, demands scholarship of a high order, and emphasizes research and creativity. It involves a minimum of formal requirements and regulations, and a maximum of student initiative and responsibility.

A student does not become a graduate student merely by enrolling for advanced courses after having received a baccalaureate degree. Formal admission to the Graduate School is required.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number which can be accepted will vary with departments and from term to term. In some fields all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted. The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the resources of the University to provide graduate programs of outstanding quality.

Admission is granted by the Dean of the Graduate School after approval of the application by the department in which the student plans to do his major work. Blanks to be used in making formal application for admission can be obtained from the Graduate School office. In general, a student may begin his graduate work in fall, winter, spring, or summer. Prospective students may write directly to the head of any department concerning graduate work in that specific field.

Students from other countries are encouraged to write to the Director of International Student Affairs for information concerning finances, housing, and other nonacademic matters.

CREDENTIALS—An applicant for admission should provide complete credentials, in duplicate, sent directly from other institutions to the Dean of the Graduate School at least two months prior to the opening of the term in which he plans to begin his graduate program. If the applicant has attended more than one institution, two official transcripts of the work covered at each institution are required. This applies to the complete academic record, both undergraduate and graduate.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements for an advanced degree.

UNQUALIFIED ADMISSION—For unqualified admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must have maintained during his junior and senior years a minimum grade point average equivalent to 2.5 on The Pennsylvania State University grading scale (approximately half B and half C). Finally, he must ordinarily have completed in a satisfactory manner a certain minimum of course

work in designated areas, the specific courses and amount of required work depending upon the field of advanced study which the student proposes to enter. The specific courses and the total number of undergraduate credits required can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. The minimum grade point average of 2.5 during the last two undergraduate years is a general requirement of the Graduate School. Individual departments may require a higher average for admission in their fields.

The above requirements apply particularly to the student who has recently completed an undergraduate program and is about to begin graduate study. An applicant who has done a year or more of graduate work in a recognized graduate school will be evaluated largely on the basis of the graduate record but with some attention to undergraduate achievement. For a mature person, recognized attainment in a professional field will be considered, and reduced weight will be given to old undergraduate records.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School and as a consequence will be required to cease attending any 500-level courses for which he may have registered. He may continue to attend courses below the 500 level provided he applies for and is accepted for registration as an adjunct student.

CONDITIONAL ADMISSION—When a department has space for additional students, an applicant whose grade point average is below 2.5 may be admitted conditionally for one term under the following circumstances: He must have had at least one year of significant experience after receiving the bachelor's degree and be recommended for admission by his major department. The applicant's credentials must be on file in the Graduate School office at least three months before the proposed date of registration. He must devote full time to his studies during the term for which he is conditionally admitted unless he is a student at one of the Graduate Centers or in a comparable situation where a full-time program is not available. In the latter case he may continue on a part-time basis until the equivalent of a full term has been completed. At the end of the student's first term (or equivalent first term in the case of a part-time student) his conditional admission will terminate. If an average grade of 3.0 has been earned, he may continue as a student with unqualified admission. If an average of 3.0 has not been attained, the student may not register again as a graduate student.

ADVISERS—To assist the student in planning his program, the head of his major department will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to make an appointment for an initial language proficiency interview at the Language Testing Center for International Students, 218 Sparks Building. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. Remedial work will be prescribed as indicated by the tests.

GUESTS OF THE UNIVERSITY—The President, on recommendation of the Dean

of the Graduate School, will welcome as guests holders of earned doctors' degrees who may be visiting the University for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses, and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade point average of 3). Any senior with a 3.5 grade point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400 and 500 series courses toward an advanced degree at Penn State. Upon admission to the Graduate School such credits as are relevant to the graduate field of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major and minor departments. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

STUDENT CONDUCT

The University expects that students will conduct themselves in accordance with the standards normally followed by educated men and women and in accordance with the laws of the Nation, State, and Borough. The right is reserved to sever at any time the University connection of any student whose influence is found to be injurious to the standard of morals and scholarship of the student body, or whose conduct is prejudicial to the good name of the University.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

CLASSIFICATION

At the time of admission to the University students are classified as regular graduate, general graduate, adjunct, or undergradate students depending upon their objectives and qualifications.

A change in classification for a graduate student is arranged through the Graduate School office and, in the case of a change from general to regular status, the approval of the head of the major department in which the student proposes to work is required.

A person holding a baccalaureate degree and working only for permanent certification as a teacher or administrator in the public schools is advised to apply for admission as a general graduate student. Admission will be subject to the availability of space and facilities.

REGULAR GRADUATE STUDENTS—Persons who plan to become candidates for advanced degrees at The Pennsylvania State University and have been formally admitted for advanced study in a particular field are designated as regular graduate

students. The program of study is developed under the guidance of an adviser appointed by the head of the student's major department.

It should be emphasized that a student is not a "regular graduate student" unless he has been officially admitted to that status. Regular attendance in the Graduate School, or personal plans for future degree candidacy, do not in themselves carry with them the status or privileges of a regular graduate student.

A regular graduate student who has passed a candidacy evaluation is classified as a doctoral candidate.

GENERAL GRADUATE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a general graduate student. This classification includes those who plan to transfer credits to another institution and those who plan a special program of study not leading to an advanced degree. The number of general graduate students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of total enrollment. Preference is given to students in degree programs.

If a general graduate student wishes to consult an adviser, one will be appointed upon request to the department head most closely associated with the student's field of interest. The student's status and standing will be reviewed by the Dean of the Graduate School at each registration. He may remain a general graduate student longer than one term only with the permission of the Dean, and for definite and good reasons.

ADJUNCT STUDENTS—An adjunct student is not a graduate student, inasmuch as he has not been admitted to the Graduate School, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses, provided he has attained at least junior standing in college.

Credits earned as an adjunct student may not ordinarily be applied subsequently toward an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until he has met the minimum requirements for his degree, he must register for each term in which he proposes to do either course work or research, or other work on his thesis, either on or off campus. In the case of research the number of credits shall be determined by the amount of time required for the investigation, one credit representing one week of full-time graduate work.

CONTINUITY OF REGISTRATION—Any student who has interrupted the normal sequence of his graduate program is required to apply to the Dean of the Graduate School for permission to resume graduate study. It is recognized that certain students typically will not attend the summer terms whereas others will concentrate their work in these terms. Both groups, as well as certain variants, meet the spirit of the policy.

In order to register for a given term, a student who has been previously enrolled will need to apply unless he has been registered for work at University Park, for thesis research in absentia (610), or for other Penn State work off campus during certain specific terms as follows:

Summer Term—Application required unless the student was registered for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered for the preceding fall term.
Spring Term—Application required unless the student was registered for the preceding winter term.

Application should be made as early as possible and in no case later than two months before the time of registration.

PROCEDURE—For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs. The credit load will be reviewed by the Dean of the Graduate School at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done off the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed by the same deadline as applies on the campus.

A student must register for courses audited as well as for those taken for credit.

EXCEPTIONS—When a candidate has met minimum requirements for a degree, further registration shall be required only for course work, project work, and research work requiring the use of University facilities and supplies (including laboratory, library, and others). This means, for instance, that a student who has earned 90 credits in a doctoral program and has met all requirements for the degree except for the completion of his thesis and the passing of the final oral examination need not register for the additional research which may be required, whether it be done at University Park or elsewhere, provided he does not use University facilities or supplies. On the other hand, a student who uses University facilities or supplies for his research must be registered for credit at all times, regardless of the number of credits that may accrue before he completes his work. The same policy applies to masters' candidates.

A candidate need not register for the term at the end of which the degree is to be conferred solely for the purpose of graduating. He will, of course, be required to register if he has a significant amount of work to complete unless relieved of this obligation by the previous paragraph. He will not be required to register if he has only minor revisions of his thesis to complete and/or the final oral examination to pass.

TIME OF REGISTRATION—Registration days for all students are indicated in the University Calendar.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructors to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the amount of time which he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

LOADS, ACADEMIC AND EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule in planning his academic program.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their Graduate School experience to a maximum extent. Therefore the Graduate School reserves the right to deny admission or registration to part-time students who (a) propose schedules of few credits which seem to reflect little real interest in graduate work or would not seem to require serious effort, or (b) wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality in their graduate work.

"Doing graduate work" means more than doing what is required in courses or in research. It means living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Overloads make it difficult and often impossible to do graduate work so conceived. Hence the following "protective" schedule of permitted loads for employed students has been adopted:

EMPLOYMENT	ACADEMIC LOAD
0 hours per week	8-10 credits allowed
10 hours per week	7- 9 credits allowed
20 hours per week	5- 7 credits allowed
30 hours per week	4- 5 credits allowed
40 hours per week	1- 4 credits allowed

This means, for example, that anyone working 20 hours per week (about half-time) whether as a half-time graduate assistant, as an employee on campus, or as an employee off-campus, will be limited in the amount of graduate work for which he may register to about three fifths of a normal full-time load (i.e., to 5-7 credits). The word employment is used in a very general sense and includes working for indirect compensation, such as housekeeping, working in the family business, maintaining a large vegetable garden, etc. Hence, all students who are thus employed will be expected to adjust their academic loads accordingly. Exceptions, in the case of students who have demonstrated unusual ability, must be arranged with the Dean of the Graduate School at the time of registration. (See also Visiting and Auditing Classes.)

A student holding a fellowship, graduate assistantship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no grade and cannot subsequently secure credit for work done in the course.

Ordinarily a student is not permitted to count courses for which he is registered as an auditor as a part of the minimum for which he is required to register by virtue of his status. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for the course as an auditor.

In the 1G and 2G courses offered by the language departments, visiting is not permitted and no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the lan-

guage, he will be required to count the course as a part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

SELECTIVE SERVICE—A request for deferment must be addressed to the local board by the student himself. Although the University cannot make this request, it can supply local boards with information needed in support of a request for deferment.

To have his local board informed of his formal admission to the Graduate School, a student must supply the essential Selective Service information and request the Associate Registrar to inform the board.

To have his local board informed of his registration and status as a student, a new graduate student must request the Associate Registrar to so inform the local board. If so requested, a report will be sent shortly after the beginning of the first term for which the student registers. A student is certified to be a full-time student insofar as Selective Service is concerned if he schedules at least 8 credits (auditing a course does not count), or if he holds an appointment as a quarter-time or half-time graduate assistant, or if he is serving an internship or holding a traineeship under approved conditions.

If at any time a student changes his status from full-time to part-time, fails to make satisfactory progress, or makes a drastic change in his declared goal, his local board will be notified. If a student changes his status from part-time to full-time and wishes the local board to be informed, he must request the Associate Registrar to do so. When a student receives a master's degree, it will be assumed his program is terminated, and his board will be so informed unless there is clear prior indication in the Registrar's Office of the student's intention of proceeding with a doctoral program.

At the end of each spring term the Registrar's office reports to the local boards the status of all graduate students for whom a report was made during one of the three previous terms.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade point equivalents are 4, 3, 2, 1, 0 respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade point average of 3.0 for work done at this University is required for graduation in the case of all candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later.

In addition to the quality grades listed above, two symbols, "deferred" and R, may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "deferred" in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, the instructor may report the symbol R in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. An R remains on the student's transcript permanently. If, after having

submitted a series of R symbols, the instructor reports a grade of A, B, C, D, or F for a specific term, this grade is considered to apply to the preceding series of registrations and to denote the quality of that entire series.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate (by filing a diploma card or, if a diploma card is already on file, by requesting that it now be transferred to the active file), and to pay thesis fees at the beginning of the term in which he expects to receive an advanced degree. Deadlines are given in the calendar.

See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation. Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School.

All degrees conferred are tentative until final grade reports have been received even though the student's name may have appeared in the commencement program.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus—8 or more credits, total charge of $150 for Pennsylvanians and $450 for non-Pennsylvanians; 7 or fewer credits, $22 per credit for Pennsylvanians and $44 per credit for non-Pennsylvanians.

Off-Campus Research—$22 per credit for 1 to 7 credits for all students; $150 for 8 to 10 credits.

Vocational Education Programs—7 or fewer credits, $22 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether taken as an auditor or for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than 10 days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Director of Admissions for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile of the one admitted (or of his parents, if he is a minor) within the Commonwealth for a period of at least 12 months immediately preceding the date of such petition for reclassification; and, in addition, such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following the twelfth month after such change has taken place.

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor not later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIAL CHARGES (payable as occasion demands and applicable to all students):

Admission to the Graduate School	$10.00
Privilege of late registration	10.00
Privilege of late payment	25.00
Change of schedule, each change	2.00
Thesis binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Official transcript of record (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

A graduate student planning to operate a motor vehicle in the State College area should secure a copy of the leaflet *Parking and Traffic Regulations* from the Traffic Violations Officer, Room 203D, Hetzel Union Building.

TAXES—Depending upon their residence classification and appointment status, graduate students may be subject to taxes while at the University. In general, graduate assistants will be liable for the federal income tax and the State College borough wage tax on their stipends. A graduate student who is classified as a resident of one of the civil subdivisions of Centre County may also be subject to local taxes, including school tax. Details are given in the *Manual for Graduate Students.*

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fireproof, one-story, steel framework buildings. Forty-six one-bedroom units rent for $75 per month and 32 two-bedroom units

rent for $85. The rent includes utilities except for electricity. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle, opened in 1960, has 144 one-bedroom and 72 two-bedroom apartments in 16 two-story buildings of brick and frame construction. The units rent for $82.50 and $92.50 per month, including all utilities. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator, and each bedroom has a built-in chest of drawers; otherwise the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age or with children who will become school age during the term of the lease cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children. An application form for a Married Student Apartment may be obtained by writing to the Department of Housing and Food Services, Assignment Office, 23 Pollock Hall, University Park, Pa., 16802. Telephone: Area Code 814, 865-7501.

Atherton Hall, located near the Hetzel Union Building and reserved exclusively for single graduate men and women, provides residence hall room accommodations without food service. Double, single, or single occupancy of double rooms are available at $125, $140, and $150 per term respectively. The Hetzel Union Building cafeteria and snack bar are available for meals.

Separate dining hall meal tickets for one of eight campus dining halls may be purchased for $175 per term. Twenty-one meals per week are served beginning with registration and ending with final examinations.

For other information on the residence or dining halls, contact the Assignment Office, 23 Pollock Hall, University Park, Pa., 16802; telephone Area Code 814, 865-7501.

Information on other living accommodations available in the community may be obtained through the Chamber of Commerce, 129 W. Beaver Ave., State College, Pa., 16801; telephone Area Code 814, 237-7644. The cost of apartments or rooms in private homes or lodging houses varies considerably depending upon the type of accommodations desired, and arrangements can best be made by personal visit to the area.

Prospective graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be very difficult to find convenient housing at the last minute.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

ASSISTANTSHIPS

Approximately 1,400 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some departments. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department for information and application forms. Appointments are made upon the recommendation of the department head, subject to admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship requires a continuing demonstration of good scholarship.

The assistantships vary as follows:

QUARTER-TIME—The student may schedule 7-9 credits, receives a stipend in the range $270-$480 plus a grant-in-aid which covers tuition, will be required to give a maximum of 10 hours of service per week for 12 weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

HALF-TIME—The student may schedule 5-7 credits, receives a stipend in the range $480-$1,020 plus a grant-in-aid which covers tuition, will be required to give a maximum of 20 hours of service per week for 12 weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

THREE-QUARTER-TIME—The student may schedule 4-5 credits, receives a stipend in the range $810-$1,350 plus a grant-in-aid which covers tuition, will be required to give a maximum of 30 hours of service per week for 12 weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by arrangement with the Dean of the Graduate School, provided the credit load and the service load are properly balanced in each term, and the total credit load over a series of terms is in conformity with the specified limits.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term without service, if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an extra earned grant-in-aid form from the head of the department in which he has held the assistantship and must follow the instructions on the form in making application.

A graduate assistant may not accept additional employment, either at the University or elsewhere, during the period for which service to the University is required under the appointment (12 weeks per term).

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than 400 fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows and trainees carry a full-time graduate program, receive a stipend which varies with the award, and usually receive a grant-in-aid paid by the donor of the fellowship to provide for all tuition. They may not accept employment during the term of their appointment (except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

GRADUATE SCHOOL FELLOWSHIPS—Eleven fellowships, each paying a stipend of $2,000 for the fall, winter, and spring terms, and providing a grant-in-aid to

cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding advanced graduate students in any field, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences. An applicant must have completed at least one full year of graduate study prior to beginning the fellowship tenure and be a candidate for the doctoral degree.

Applications should be addressed to the Dean of the Graduate School and must be received by February 15 to be considered for the following fall, winter, and spring.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES—At least 230 such awards, with various stipends, are granted through individual departments. Information and application forms may be secured from the head of the major department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1965-66:

Amelia Earhart Fellowship—Available to women graduate students in aeronautical engineering; stipend $2,400.

American Chemical Society Fellowship—Open to graduate students in chemistry and chemical engineering; stipend $1,800-$2,400.

American Chemical Society Fellowship—Open to graduate students in fuel technology; stipend $2,280.

American Chemical Society Fellowships (2)—Open to graduate students in geochemistry, mineralogy, and solid state technology; stipend $2,400.

American Chemical Society Fellowship—Open to graduate students in geology; stipend $2,400.

American Cyanamid Fellowship in Chemistry and Chemical Engineering—Open to graduate students for the final year of study leading to the Ph.D. degree. Awarded in alternate years to a chemist and to a chemical engineer; stipend $1,800.

American Iron and Steel Institute Fellowships (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400.

American Petroleum Institute Fellowships (5)—Open to graduate students in chemistry and physics for research concerning the synthesis and properties of high molecular weight hydrocarbons; stipend $1,710-$2,280.

American Petroleum Institute Fellowships (2)—Open to graduate students in geochemistry, ceramic technology, mineralogy, and solid state technology for research concerning the synthesis and properties of clays and related inorganic phases; stipend $2,640.

American Petroleum Institute Drilling Research Fellowship—Open to graduate students in mining or petroleum and natural gas engineering for studies related to drilling and rock penetration; stipend $2,400.

Armstrong Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry; stipend $640.

Atomic Energy Commission Graduate Traineeships in Nuclear Reactor Operations and Utilization (5)—Available to graduate students in nuclear engineering. Stipends comparable to the AEC Special Fellowships.

Carborundum Corporation Fellowship—Available to a graduate student in mineral preparation; stipend $2,400.

Continental Oil Company Fellowship—Available to graduate students in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

Continental Oil Company Fellowship in Petroleum Economics—For graduate work in mineral economics on petroleum economics; stipend $2,280.

du Pont Fellowship in Mechanical Engineering—Open to a graduate student in mechanical engineering; stipend $2,400.

du Pont Summer Fellowships (4)—Open to graduate students in chemical engineering; stipend $300-$600.

Esso Research and Engineering Postgraduate Fellowship in Chemistry and Chemical Engineering—Open to advanced graduate students for one year of study leading to the Ph.D. degree; stipend $1,800-$2,400.

W. S. Elliott Fellowship—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

Ford Motor Company Fellowship—Open to a graduate student in mechanical engineering; stipend $2,400.

General Foods Fund Fellowships (2)—For graduate work with a major in home economics; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

Gulf Oil Company Fellowship in Petroleum and Natural Gas Engineering—For graduate work in petroleum production; stipend $2,400.

Hamilton Standard Fellowship—Open to graduates of this University in aerospace, electrical, and mechanical engineering, engineering mechanics, and physics; stipend $1,800.

H. R. Imbt Services, Inc., Fellowship—For graduate work in civil engineering in the field of civil engineering construction; stipend $2,400.

International Business Machines Corporation Fellowship—Open to an outstanding advanced graduate student in the humanities or social sciences when his doctoral research is amenable to treatment by a digital computer; stipend $1,800-$2,500. Apply to the Dean of the Graduate School.

International Lead Zinc Research Organization Fellowships (2)—In support of research on the physics and chemistry of lead and zinc compounds. Open to students in solid state technology and allied fields; stipend $2,540.

Koppers Summer Supplemental Teaching Fellowships (2)—Open to a graduate student in chemistry and a graduate student in chemical engineering; stipend $600.

Lead Industries Association Fellowship—Open to graduate students in ceramic technology for studies of lead oxide systems; stipend $2,208.

Marathon Oil Company Fellowship—Available to graduate students in petroleum and natural gas engineering; stipend $2,280.

Monsanto Summer Research Fellowships (2)—Open to graduate students in chemistry; stipend $650.

National Steel Corporation Fellowship—Available to a graduate student in metallurgy; stipend $2,880.

Edward Orton, Jr., Ceramic Foundation Fellowship—Open to students in ceramic technology for studies relating to kiln-fired ceramic bodies; stipend $2,400.

Owens-Corning Fiberglas Fellowship in Ceramic Technology—Open to graduate students in ceramic technology; stipend $3,000.

Owens-Illinois Fellowship—Open to graduate students in ceramic technology for studies in glass science and technology; stipend $3,000.

Pennsylvania Cooperative Fishery Unit Fellowship—Available to graduate students in zoology; stipend $2,400.

Pennsylvania Cooperative Wildlife Research Unit Fellowships (4)—Available to graduate students in forestry, zoology, and related fields; stipend $2,400.

Pennsylvania Electric Association Fellowship—For graduate work in mineral economics on potential markets for fly ash; stipend $2,400.

Pennsylvania Natural Gas Men's Fellowship—For graduate work in petroleum and natural gas engineering for studies in gas technology; stipend $2,000.

Radio Corporation of America Fellowship—Open to graduate students in electrical engineering; stipend $2,100-$3,000.

Shell Companies Foundation Fellowships (2)—Open to advanced graduate students in two of these fields in rotation: chemical engineering, chemistry, and petroleum engineering; stipend $2,000-$3,000.

Socony-Mobil Fellowship—Available for graduate students in chemical engineering; stipend $1,500-$2,000.

Speer Carbon Fellowship—Open to graduate students in fuel technology for studies on carbon; stipend $2,400.

Stackpole Carbon Fellowship—Open to a graduate student in fuel technology for studies on carbon; stipend $2,808.

Stackpole Ferrite Fellowship—Open to students in ceramic technology and solid state technology; stipend $3,000.

Sprague Electric Company Fellowship—Open to students in ceramic technology and solid state technology; stipend $2,400.

Stauffer Chemical Company Fellowship in Chemistry—Open to a graduate student in chemistry for research on organometallic compounds; stipend $1,800.

Sun Oil Company Fellowship in Chemistry—Open to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

Texaco Fellowship in Geophysics—Available to a graduate student in geophysics; stipend $2,760.

Union Carbide Summer Fellowships (4)—Open to graduate students in chemical engineering; stipend $300-$600.

U. S. Office of Education Fellowships in Speech Pathology and Audiology (5)—Open to graduate students majoring in this field; stipend $2,000-$2,800 plus dependency allowance.

U. S. Office of Education Fellowships in Education of Exceptional Children (8)—Open to graduate students being prepared as leadership personnel in the education of the mentally retarded and the speech handicapped; stipend $2,000-$2,800 plus dependency allowance. Apply to the head of the Department of Special Education.

U. S. Public Health Service Traineeships in Clinical Psychology (12)—Open to selected graduate students in this area of psychology; stipend $1,800-$3,000.

U. S. Public Health Service Traineeships in Microbiology—Open to selected graduate students in microbiology; stipend $2,400-$2,700.

U. S. Public Health Service Traineeships in Public Health Nutrition—Open to selected graduate students in foods and nutrition; stipend $3,000.

U. S. Public Health Service Traineeships in Sanitary Engineering—Open to graduate students in sanitary engineering; stipend $3,600-$5,000.

U. S. Public Health Service Traineeships in Zoology (4)—Open to selected graduate students in zoology; stipend $2,400.

United States Steel Foundation Fellowship—Open to graduate students in the College of Mineral Industries for studies related to steel-making; stipend $2,880.

U. S. Vocational Rehabilitation Administration Traineeships in Speech Pathology and Audiology (11)—Open to graduate students majoring in speech pathology and audiology; stipend $2,400-$2,800.

U. S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in Counselor Education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (18)—Open to selected advanced graduate students in this area of psychology.

Wheelabrator Fellowship—Open to graduate students in industrial engineering, mechanical engineering, and metallurgy; stipend $1,500.

In addition, numerous grants are available from governmental agencies, industrial concerns, and foundations for the support of investigations of particular problems. Many of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS—Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration:

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelors' degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Institute of Nuclear Studies, Oak Ridge, Tennessee. About 200 will be awarded.

National Aeronautics and Space Administration Predoctoral Traineeships in Space-Related Science—The National Aeronautics and Space Administration awards training grants to various recognized universities to increase the supply of scientists and engineers in space-related science and technology in order to meet the growing needs of the federal government's space research program. These grants permit a university to award a specified number of traineeships in science and engineering fields. The awards compare favorably with the best fellowships. In 1965-66 the University had 37 of these traineeships in physical science and engineering fields. More may be available for 1966-67. No institution will know whether it has any available until late in the fall. Applicants should write to the graduate dean at the institution of their choice, or to the head of the department in their graduate field. More than 1,200 were awarded in 1965.

National Defense Graduate Fellowships—Under Title IV of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education makes an allotment of three-year fellowships to approved institutions which have applied for them and designates the major fields among which the awards may be distributed. One purpose of these awards is to assist able graduate students who certify their interest in college or university teaching to obtain their doctorates, thus increasing the higher education teaching staff nationally. The program also aims to increase the development and utilization of doctoral degree training facilities and promote their wider distribution geographically.

Seventy-five per cent of these fellowships in an institution must be awarded to students beginning graduate study in September; the remainder may be awarded to those who have completed no more than two years of graduate study by September. These awards compare favorably with the best fellowships available. The University had 51 students studying under these fellowships in 13 different fields of the arts and sciences in 1965-66.

No institution knows until the fall of each year whether it will have any additional fellowships under this program for the following year. A senior or an interested graduate student should inquire from the head of his actual or anticipated graduate major department. Applications will be made directly to the departments or graduate deans of institutions having programs in the desired field. Most institutions have application deadlines from February 15 to 20. Approximately 6,000 of these fellowships will be awarded for 1966-67.

National Defense Modern Foreign Language Fellowships—Under Title VI of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

Late in the fall the Commissioner of Education announces the institutions, the quotas of fellowships, and the specific language and area programs to which the fellowships are allocated. (In 1965 announcement was made December 1.)

In 1965-66 the University had a few in Russian language and area studies. A few may be available for 1966-67 in this program only. Write to the Head of the Department of Slavic Languages, 127 Sackett Building.

Approximately 1,300 will be awarded for 1966-67.

National Science Foundation Graduate Fellowships—The Graduate School cooperates in this program of prestige fellowships, requiring outstanding credentials, and available in the biological, engineering, mathematical, and physical sciences, anthropology, economics (excluding business administration), geography, history and philosophy of science, political science, psychology (excluding clinical), and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, and meteorology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington, D. C., 20418, which has charge of evaluating applicants for the Foundation. The application deadline is usually about December 10. About 1,100 new awards will be made for 1966-67.

National Science Foundation Graduate Traineeships—This program has been expanded for 1966-67 to include all the areas supported by the Graduate Fellowship Program mentioned above. The National Science Foundation awards training grants to various recognized universities to accelerate the output of graduate students in these fields and to help meet the Nation's future needs for scientific and professional manpower. These grants permit a university to award a specified number of traineeships, 80 per cent of which must go to first-year graduate students. These awards compare favorably with the best fellowships. In 1965-66 the University had 40 of these traineeships in engineering, mathematics, and physical science. More will probably be available in many of the above areas for 1966-67. No institution will know until the middle of January whether it will have any available. Applicants should write to the graduate dean at the institution of their choice, or to the head of the department in their graduate field. About 2,100 new awards will be made for 1966-67.

National Science Foundation Science Faculty Fellowships—These awards are made to enhance the effectiveness of college faculty members who have at least three years' experience as full-time staff members, teaching science, mathematics, or engineering mainly to undergraduates. They are awarded to those working for a Ph.D., or to those holding the degree and teaching in any of the fields supported by the NSF Graduate Fellowship Program. Tenure may be from 3 to 15 months and can be spread over three successive summers. About 350 will be awarded for 1966-67. Write the National Science Foundation, Washington, D.C., 20550. The application deadline for 1967-68 will be about the middle of October, 1966.

Study Fellowships for International Development—The Inter-University Committee on Study Fellowships for International Development, supported by a grant from the Ford Foundation, makes these awards for one year of graduate study, usually toward the master's degree, to United States and Canadian citizens under 35 years of age who have served in a volunteer capacity for more than one year in one of the developing countries and wish to devote a significant portion of their careers to overseas development assistance. Fields of study include such areas as agriculture, business administration, community development, economics, engineering, English (to be taught as a second language), political science, public administration, and public health. The universities cooperating in this program are U.C.L.A., Chicago,

Columbia, Cornell, Harvard, North Carolina, Penn State, Stanford, and Wisconsin. About 60 fellowships will be awarded for 1966-67. Applications may be obtained from the central office for the program: Study Fellowships for International Development, 115 Sackett Building, The Pennsylvania State University, University Park, Pa., 16802; or from overseas representatives of the Peace Corps. Completed applications for 1966-67 must be received at the above address before February 7, 1966.

U. S. Public Health Service Predoctoral Fellowships—Available to graduate students in anatomy, anthropology, behavioral sciences, biochemistry, biomedical engineering, biophysical sciences, biostatistics, botany, developmental biology, endocrinology, entomology, genetics, history of life sciences, medicinal chemistry, microbiology, nursing, nutrition, organic chemistry, pathology, pharmacology, physiology, social and psychological sciences, zoology, and air and water pollution. These fellowships are used at the university of one's choice and are more frequently awarded to second or third year graduate students. Prior to formal application a senior must have been admitted to a graduate school and must have obtained a sponsor there who will supervise his training. Application should be made to the Career Development Review Branch, Division of Research Grants, National Institutes of Health, Bethesda, Md., 20014, by December 15 for awards announced in the spring; by March 15 for summer awards; and by September 15 for winter awards. Approximately 2,000 will be awarded for 1966-67.

Woodrow Wilson National Fellowships—Awarded by the Woodrow Wilson National Fellowship Foundation for first-year graduate study at the institution of one's choice, to outstanding students who show a clear preference for a career in college teaching, especially in the areas of the humanities and social sciences. Science and mathematics majors will be considered; but they must also apply for a National Science Foundation Fellowship, and if it is received, they must accept it in preference to the Woodrow Wilson award. Students must be nominated by a professor in their undergraduate college. The nomination is sent to the regional representative of the Woodrow Wilson Fellowships for the area in which that college is located. Interested students should consult the dean or other official of their college, or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J. Nominations must reach the regional chairman by October 31, each year. Approximately 1,000 fellowships are awarded.

OTHER AIDS

COUNSELORSHIPS FOR MEN—A number of appointments are available to men graduate students to serve as Resident Counselors in the undergraduate residence halls for men. A counselor's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training and experience in personnel work are desirable, though not essential.

These appointments are for three terms (fall, winter, and spring). Remuneration is in the form of room, board, and exemption from the additional out-of-state tuition, if applicable. In addition, a grant-in-aid for full tuition is available to a limited number of the Resident Counselors selected. A counselor may not hold a fellowship or assistantship during the term of his appointment as a counselor. He may not engage in any other form of part-time employment. He may carry 7 to 9 credits per term.

Requests for information and application forms should be addressed to the Dean of Men, 117 Old Main.

SENIOR RESIDENT POSITIONS FOR WOMEN—Full-time salaried appointments as Senior Residents in undergraduate halls for women are available to qualified women graduate students. Responsibilities include working with student groups in a programming capacity, counseling, and supervising the residence hall during the

evening. Preference is given to persons working for a master's degree in higher education, specializing in student personnel administration.

These positions permit the holders to take 4 graduate credits per term at $5.50 per credit. Appointments are made for the fall, winter, and spring terms. Special arrangements of hours of work and credits may be made for the summer term. It is thus possible to complete work for a master's degree in two calendar years.

Requests for information and application forms should be addressed to the Dean of Women, 111 Old Main.

GRADUATE GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on the basis of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed 10 hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $150 per term, to non-Pennsylvanians, $450 per term. A few grants are available for students beginning graduate study in the winter or spring term, if applications are filed six weeks before registration for that term.

Applications should be addressed to the Dean of the Graduate School and must be received by March 15 to be considered for the following summer or fall.

DU PONT TEACHING AWARD IN CHEMISTRY—To be eligible for the E. I. du Pont de Nemours and Company Postgraduate Teaching Assistant Award, a graduate student must be currently serving as a part-time teaching assistant and preferably should have had two years of experience in this capacity. The recipient receives $1,200 in addition to the regular stipend paid him as a teaching assistant.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP—Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is $1,500 for a tenure of three terms plus a grant-in-aid for tuition.

JOHN W. WHITE FELLOWSHIPS—Awarded to two or three graduates of The Pennsylvania State University each year on the basis of scholarship, need, character, and aptitude. The recipients may enroll in any approved college or university. Application is made to the Office of Student Aid, 218 Willard Building.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded annually through individual departments. A request for information should be directed to the department head in the field of the student's major interest.

A.A.U.W. SCHOLARSHIP—The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

LOANS ADMINISTERED BY THE UNIVERSITY—The Director of the Office of Student Aid has charge of all loans administered by the University, for both undergraduate and graduate students. Applications may be obtained from his office, 218 Willard Building. Funds are available from three sources:

University Loan Funds have been established through the generosity of University organizations, alumni, faculty, staff, and friends. Graduate students without assistantships who are registered for a full credit load may obtain long-term loans, while graduate assistants who are classified as full-time students by the Dean of the Grad-

uate School may qualify for only short-term loans from these funds. Applicants must demonstrate a need for financial assistance in meeting University-related expenses and be United States citizens, except that international students may qualify for short-term loans if they can secure a responsible resident of Pennsylvania as cosigner of the note. The interest on long-term loans does not begin until after graduation and generally is at a low rate for the first two years.

National Defense Education Act Loan Funds are available for United States citizens from the Federal Government, this act having been expanded in the fall of 1964, to increase the amount allotted to each institution and to increase the ceiling on loans to graduate students to $2,500 per year. The forgiveness of half the loan over a five-year period for those entering teaching has been extended to college teaching and to teaching in private elementary and secondary schools, as well as to teaching in public elementary and secondary schools. Interest at 3 per cent does not start until one year after the borrower ceases to be a full-time student. Repayment in 10 annual installments then begins. Of course, repayment may be made sooner if desired.

The Alumni Graduate Student Loan Fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School Alumni who have received their bachelor's degrees elsewhere. The Graduate Student Association has also made sizable contributions to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and microfilming fee, job interview travel, etc. Students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

STATE HIGHER EDUCATION LOAN PLANS—A number of states have passed laws which enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in that state to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for legal residents of this State. A full-time graduate student may borrow up to $1,000 per year, the total not to exceed $5,000. To be eligible, a part-time graduate student must be enrolled for at least 6 credits and is limited to $500 per year. The student is required to pay 5 per cent simple interest on the loan each year he is a borrower. No payment on the principal is due until six months after the date the student has completed his course of study, with payments extended over a five-year period. It is possible that in the future some of the interest may be paid by the Federal Government under the Higher Education Act of 1965. Application may be made at any participating bank in Pennsylvania. For information, write to the Pennsylvania Higher Education Assistance Agency, Education Building, Harrisburg, Pa., 17126.

Residents of other states should inquire from their state education departments regarding the existence of similar plans. Some of the Eastern states having such plans are: Connecticut, Maine, Massachusetts, New Hampshire, New York, Ohio, Rhode Island, and Virginia.

ASSURED EDUCATION PLAN—The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his 68th and 61st birthdays respectively. Payments are handled through the Girard Trust Bank, Philadelphia, Pa. Further information and application forms may be obtained from the Office of the University Bursar, 3 Willard Building. Signed agreements

should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly.

A student who holds a graduate assistantship, fellowship, or traineeship may not accept employment, either at the University or elsewhere, during the period of his appointment, except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs.

The Office of Student Aid, 218 Willard Building, offers assistance to students in finding part-time employment in town as well as on the campus.

VETERANS BENEFITS—The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws.

Under Public Law 550, a student is classified as to his rate of training on the basis of the type of program he is following and the number of credits for which he registers.

STUDENT SERVICES

HEALTH CENTER—The services of the Ritenour Health Center are available to graduate students registered for 8 or more credits and to all graduate assistants, fellows, and other holders of graduate tuition grants.

Students are entitled to five days' free treatment in the University Hospital each term. For each day of confinement in excess of five days a charge of $10 will be made. Almost all modern drugs are furnished free of charge as required for treatment, but the student may be charged extra for medication where such treatment is unusual or extremely expensive. Consult the *Manual for Graduate Students* for details concerning facilities and services.

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY—The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general educational work of the University.

Therefore any student who desires insurance protection while in attendance at the University (1) against personal injury and/or (2) against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

HEALTH INSURANCE PLAN—A voluntary Accident and Sickness Insurance Plan with a variety of benefits is available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center. The Undergraduate Student Government, which operates the plan, has offices in Room 203A Hetzel Union Building, University Park, Pa., 16802. Telephone: Area Code 814, 865-4952.

PLACEMENT SERVICE—The University Placement Service, in cooperation with all the Colleges and departments of the University, assists both graduate and undergraduate students in finding appropriate employment upon graduation. In addition, services are extended to alumni. Several services are offered: (1) career counseling concerning career planning, career opportunities, employer characteristics, and employment trends; (2) a library of information about employers, employment trends, and career opportunities; (3) the scheduling of interviews with employers visiting the campus; (4) an extended file of employment opportunities for which a student

may apply by mail; (5) a listing of summer jobs and internships appropriate to the student's career interests; and (6) conducting of appropriate research. These services are closely coordinated with the Division of Counseling.

Contact is maintained with several thousand employers in education, industry, and government. Information concerning employment opportunities is routinely distributed to all academic departments.

The general placement section concentrates on employment possibilities in industry and government. The teacher placement section concentrates on administrative, teaching, and service opportunities in universities as well as in elementary and secondary schools.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths serve the student body. Many other religious organizations, including denominational and interdenominational groups, are active on the campus and in association with local churches.

STUDENT AFFAIRS—The Graduate Student Association is the official University-wide organization of graduate students. All students have membership in the Association, which promotes the general welfare and the academic interests of graduate students. It publishes the *Graduate School Newsletter*, helps to sponsor the Graduate School lecture series, and sponsors social functions.

MASTERS' DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees: academic and professional. Of the nine masters' degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forestry, and Master of Public Administration.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE POINT AVERAGE—A minimum grade point average of 3.0 for work done at this University is required for graduation in the case of all candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION—In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the field in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of field and can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. An applicant who meets the minimum grade point average but is

deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the minimum period of residence. An applicant for admission to the M.Ed. program in most major fields is required to have had at least 18 credits in education and related psychology, and in certain major fields may be required to have had practice teaching.

After a student has been admitted as a regular graduate student, he should confer with the head of his major department concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department.

TRANSFER CREDIT—Subject to the limitations given below on the use of credits earned away from the University Park Campus, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. When transfer credits are accepted at the time of admission, the student is not really assured of their applicability in his program until he has consulted his adviser and the details of his graduate program have been worked out.

M.A. and M.S.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus. A candidate must present a major and either a minor field of study or an approved group of general studies. A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to but different from that of the major. A general studies group consists of no fewer than 6 credits in fields other than that designated as the major field and considered by the major department to have significance and value for the candidate.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major field. A thesis is required of all candidates for the degree of Master of Science and of most candidates for the degree of Master of Arts. Details are given in the introductory paragraphs under the major field headings in the latter part of this bulletin. If a student is required to write a thesis, he must complete at least 6 credits of thesis research (600 or 610).

Those candidates who are not required to write a thesis must present a suitable essay or term paper. Its nature and extent shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The department may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department in which the candidate's major work is taken. Under certain conditions a student may complete the

thesis off-campus. To do so he must make satisfactory arrangements in advance with both the major department and the Dean of the Graduate School.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

M.Agr.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Agriculture have a professional orientation and provide training for increased competence in the various fields of agriculture. They should be clearly distinguished from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which at least 12 must be in 500-level courses and the remainder in 400-level courses. A minimum of 20 credits must be earned on the University Park Campus and at least 12 must be earned outside the candidate's major field.

In addition to credit requirements, a candidate must present a paper on a selected professional problem comparable in quality to a thesis in which he applies scientific methods to the solution of a problem. He must demonstrate ability to (a) formulate and state meaningfully the problem and objectives, (b) critically analyze the present state of knowledge of the problem, (c) acquire and analyze information to help solve the problem, (d) draw logical conclusions, and (e) interpret the relationship between the findings and professional problems. The paper will be evaluated by a committee appointed by the Dean of the Graduate School.

The candidate is required to pass a final examination administered by a committee of three faculty members appointed by the Dean of the Graduate School with at least one member from a department other than that of the candidate's major field.

M.B.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Business Administration are designed to develop advanced professional competence in the various fields of business administration. They should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Science and Doctor of Philosophy with a major in Business Administration.

The programs require a minimum of 36 graduate credits of which at least 18 must be at the 500 level and at least 26 must be earned on the University Park Campus. Candidates who enter this program without undergraduate training in business administration may be required to take up to 21 credits of preparatory courses.

Moreover, a candidate is required to present a project paper, comparable in quality and scope of work to a graduate thesis, concerning a problem of a company.

After substantially completing his course requirements, a candidate must pass a comprehensive examination to be administered by a committee composed of graduate faculty members, the first part being written and the second part oral. During these examinations the candidate will be expected to demonstrate his ability to integrate the knowledge gained in the several functional areas of business in a manner which reflects a broad knowledge of his professional responsibilities.

Applicants for the various graduate programs in business administration are required to take the admission test for graduate study in business given by the Educational Testing Service.

M.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the several fields of education. They should be distinguished carefully from the research-oriented programs which lead to the aca-

demic degree of Master of Arts or Master of Science. In most major fields the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned on the University Park Campus and at least 24 must be in course work.

At least 15 credits in 500 series courses is required except in those fields for which the Dean has approved the waiving of this requirement for an experimental period of five years.

MAJORS IN THE FIELDS OF EDUCATION—A student may major in one of the approved fields of education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate department of education.

A program of this type requires at least 6 credits to be earned outside the fields of education.

MAJORS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as chemistry, mathematics, or German, may choose such a field as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose such a major as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits will probably be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology. However, if his educational foundations background is judged to be adequate, the candidate may be approved for work in any field of education.

THESIS OR TERM PAPER—Six credits may be granted for an approved thesis. Those candidates who do not elect to write a thesis are required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department to require one or more copies of such an essay for its library or other files.

M.Eng.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which at least 12 must be earned in graduate courses (500 series), and at least 6 must be earned outside the candidate's field of concentration.

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a

graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

M.F.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in Art, Music, or Theatre Arts.

A minimum of 48 credits is required to complete the program. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Forestry provide training for increased professional competence in the several specialized areas of forest resource management and forest products. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science with a major in forestry.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.P.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration at local, state, national, and international levels or with private and voluntary agencies. This program should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may also specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required of which at least 6 must be devoted to either a thesis or an internship. Students with extensive government experience will write a thesis; others will serve an internship and write a critical review of the experience, the review to be comparable in quality to a thesis. A comprehensive final examination will be required of all students, the examination to be written, oral, or both.

No work for this degree is required to be done specifically on the University Park

Campus provided the major department or supervising committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

The degree is a terminal one and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred. The two programs are recognized as different in purpose and consequently have different requirements in certain respects.

ADMISSION—A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major field in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department and is given near the end of the first, or at the beginning of the second, year of graduate work including that done for the master's degree and work done elsewhere as well as here (i.e., at about the time he has earned a total of 30 graduate credits).

A new student transferring from another graduate school with 30 or more transfer credits must take this examination before he has earned more than 10 credits here.

There are no specific admission requirements in education and related psychology for the degree of Doctor of Education unless specified by the department or committee in charge of the particular major field. When such requirements do exist, they are listed in the introductory paragraphs under the major field headings in the latter part of this bulletin.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure the attainment of the doctorate. The general requirements are based upon a period of residence, the passing of comprehensive examinations, and the writing of a satisfactory thesis. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE POINT AVERAGE—A minimum grade point average of 3.0 for work done at this University is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later.

TIME LIMITATION—A student who was formally accepted as a doctoral candidate on or after June 1, 1963, is required to complete his program within seven years from the date of his acceptance as a candidate. A student who was admitted to doctoral candidacy, formally or informally, prior to June 1, 1963, is required to complete his program before July 1, 1971.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research, or their equivalent in credits, is required for a doctor's degree. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being

devoted to graduate study. The D.Ed. candidate may meet the residence requirement by enrollment in the summer terms, but increasingly departments are insisting upon the same requirements as for the Ph.D.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term and three such terms will meet the minimum residence requirement for the Ph.D.

OFF-CAMPUS AND TRANSFER CREDITS—A maximum of two full academic years of work beyond the baccalaureate in another approved school granting the doctorate in the major field may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. Not more than one year of work beyond the baccalaureate at a graduate school not granting the doctorate in the major field will be accepted here to apply toward doctoral degree requirements. Work beyond the master's will not be transferred if taken more than five years before beginning work for the doctorate at The Pennsylvania State University. Credit for courses and research work done elsewhere can be used to meet degree requirements, however, only if the work is appropriate to the candidate's proposed program of study as determined by his doctoral committee.

By securing the maximum allowable number of transfer credits, it is possible theoretically to complete the requirements at this institution in three terms. In practice, however, this is rarely possible because of the sequence required in courses and examinations, special departmental requirements, and the possibility of protracted research. It must be remembered that the quality of the program rather than the time requirement is of paramount concern.

Subject to the approval of his adviser, the head of his major department, and the Dean of the Graduate School, a student may register for research to be done away from the University Park Campus. Such work will not be approved, however, simply because the arrangement is convenient for the student; scholarly considerations must determine the choice of location. A doctoral candidate may register for a maximum of 30 credits of research in absentia, but these credits must be included in the 60 credits which a candidate may earn in study away from the University Park Campus. The maximum load permitted a student who is employed full time is 4 credits in a term.

With the approval of his committee, a candidate may apply toward the minimum requirements of a doctor's degree a maximum of 10 credits earned in Continuing Education classes or at the Commonwealth Campuses of The Pennsylvania State University. Credits so earned as a part of a master's degree program must be included in the limit of 10.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted as a regular graduate student, he should confer with the head of his major department concerning departmental procedures and the appointment of an adviser. The arrangement and approval of the details of the term-by-term schedule of the student is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major department for this specific duty.

The general guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of five or more members of the Graduate Faculty. The committee is appointed by the Dean of the Graduate School, upon recommendation of the head of the major department, after the student is admitted to candidacy. The chairman of the committee must hold senior membership in the Graduate Faculty.

The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. At his discretion, the Dean may add other members to the committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after admission to candidacy. The committee will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

LANGUAGE EXAMINATIONS—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School and must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must show either a reading knowledge of two other languages or general competence in one other language. The languages used to satisfy this requirement must have significance in the candidate's field of study and be approved by the candidate's doctoral committee and the Dean of the Graduate School. French, German, and Russian are the languages most frequently needed and will be approved by the Dean without specific request. The use of any other language must be approved in advance.

If a candidate elects to be examined for a reading knowledge in two languages, he is urged to complete one-half of the requirement before admission to candidacy and is required to complete the whole requirement before taking the comprehensive examination. The candidate must report his intention to take the examination in reading competence to the secretary of the language department concerned during the registration period for any term during which he wishes to take it. The examination will be administered on dates announced in the graduate calendar at the beginning of this bulletin.

The reading competence option may be satisfied by the achievement of at least a grade of B in the second (2G) of two courses specifically designed for developing reading ability if a language department desires to use such a course in that way.

If the candidate elects to demonstrate a general competence in one language—i.e., the ability to communicate effectively—he is required to demonstrate competence in reading as described above before applying for examination in the remaining skills. The remaining skills will be tested at a time and place designated by the language department concerned before the candidate may take the comprehensive examination.

In general, the language requirements must be met at this University. However, if a student has passed suitable language proficiency examinations at another institution prior to admission to the Graduate School at Penn State, this may be accepted in satisfaction of requirements here.

Candidates for the D.Ed. degree may be required by their major departments to demonstrate competency in foreign languages, but there is no Graduate School requirement.

COMPREHENSIVE EXAMINATIONS—When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major and minor fields of study.

A candidate for the Ph.D. must have satisfied the language requirements before taking the examination.

All candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later are required to have a minimum grade point average of 3.0 for work done at this University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. The comprehensive examination is given and evaluated by the doctoral committee and may be either written or oral, or both. A favorable vote of at least two thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School.

In no case may the final oral examination be scheduled less than three months after the comprehensive examination.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATIONS—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. In no case may the final examination be scheduled less than three months after the comprehensive examination. The deadline for holding the examination is three weeks before Commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the whole field of study of the candidate without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

MINOR FIELDS—A minor is not required of all candidates for the Ph.D. degree. A department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and the minor fields.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal on the part of the candidate an ability to do

independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than two weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate, such as biological science, foods and nutrition, or English.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) the satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

MAJOR AND MINOR FIELDS—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major field of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education.

A candidate choosing a major in one of the fields of education must also choose either a minor or a group of general studies with the approval of the major department. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside the fields of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside the fields of education considered by the major department to have significance and value for the candidate.

COMPREHENSIVE EXAMINATIONS—In addition to demonstrating a high level of competence in the subject matter of his major and minor fields, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later are required to have a minimum grade point average of 3.0, for work done at this University, at the time the comprehensive examination is given.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. The thesis may be based upon a product or project of a professional nature, provided that scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than two weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

PROGRAMS AND COURSES

Programs of study leading to advanced degrees are offered in many major and minor fields. These are listed in the following section, and the major fields are summarized at the beginning of the following section. Related courses are grouped together under the name of the field. To locate a particular course or group of courses, consult the index.

In general, departments of the University are identified with specific major fields. Thus aeronautical engineering is a major field of study which is offered under the supervision of the Department of Aeronautical Engineering. On the other hand, biological science and comparative literature are major fields for which there are no corresponding departments. In such cases a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one field. Thus the Department of Civil Engineering offers work in both civil and sanitary engineering.

Applicants for admission are encouraged to consult the person whose name is listed under the major field heading.

DEGREES—In those major fields approved for the doctorate, the Ph.D. is normally conferred, although a program leading to the D.Ed. may also be arranged with the consent of the department or committee in charge if such a professional program is appropriate. Similarly, in major fields approved for the master's degree the M.A. or M.S. is normally conferred, but a program leading to the M.Agr., M.B.A., M.Ed., M.Eng., M.F.A., M.F., or M.P.A. may also be available. The D.Ed. and M.Ed. are not limited to the fields of education, but with the consent of the department or committee in charge may be offered in any approved major field appropriate to the preparation of teachers, such as mathematics or English. In this case the program is sponsored by a major department outside the fields of education, such as the Department of Mathematics, but the student's minor is in education.

MINOR FIELDS—All major fields listed are also acceptable as minors. In addition, a few fields in which no advanced degrees are offered have been approved as minors for candidates who are majoring in related areas. Such minor fields are identified in the summary at the beginning of the following section and by a brief statement under the field heading in that section.

A candidate's choice of minor field depends upon the particular degree he is seeking and is subject to the approval of his major department. The requirements in each minor field are established by the minor department subject to the regulations of the Graduate Faculty.

INTERDISCIPLINARY MAJORS—In addition to the majors listed on the following pages, interdisciplinary majors involving two or more departments may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental committees.

OTHER FIELDS—Fields which have not been approved for either major or minor work, but in which approved courses are offered, are listed at the end of this bulletin. These courses may be used in graduate programs as electives or as part of a general studies program, subject to the approval of the major department and to the restrictions upon the use of 400 series courses in degree programs.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 50 to 55 under the specific requirements for the various masters' degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.5, and other students who have been granted permission to enroll by the Dean of the Graduate School.

Course numbers 600 and 610 apply to thesis research and are available only to students registered in the Graduate School.

CREDITS—A credit is defined as a unit of time approximately equivalent to one week of full-time graduate study. Accordingly, a full-time student having no concurrent employment may earn a maximum of 10 credits in a 10-week term. A "credit" as used in this bulletin, therefore, is identical in meaning with a "semester credit" and should not be confused with a "quarter credit" which is associated with the traditional quarter system. By increasing the length of class periods to 75 minutes, the Penn State calendar based upon a 10-week term provides for the same amount of time in a given course as does the typical semester plan.

COURSE DESCRIPTIONS—A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department offering the course. A department may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400 and 500 series courses a department may schedule an individual student for fewer credits than the maximum number but in no case for more than the maximum number authorized.

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Timetable,* which is available at nominal cost from the Scheduling Office approximately six months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

RESEARCH AND THESIS WORK—In general, students registering for work on a master's or a doctor's thesis will, if it is to be done on the University Park Campus, use course number 600 preceded by an abbreviation designating the major field. Thus Aro.E. 600 signifies thesis research in aeronautical engineering. In case such work has been authorized for students not working on the University Park Campus, the number 610 will be used. Credits will be 1 to 10 per term.

It should be assumed that the numbers 600 and 610 are available in all fields in which majors have been approved for advanced degrees although these numbers may not appear in the timetables.

MAJOR
and
MINOR
FIELDS

GRADUATE FIELDS OF STUDY

Aeronautical Engineering—Ph.D., M.S.
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—M.S.
Agronomy—Ph.D., M.S., M.Agr.
Animal Industry—Ph.D., M.S.
Animal Nutrition—Ph.D., M.S.
Anthropology—Ph.D., M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A., M.F.A.
Art Education—Ph.D., D.Ed., M.S., M.Ed.
Art History—M.A.
Biochemistry—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Business Education—Ph.D., D.Ed., M.S., M.Ed.
Ceramic Technology—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S.
Chemistry—Ph.D., M.S., M.Ed.
Child Development and Family Relationships—Ph.D., D.Ed., M.S., M.Ed.
Civil Engineering—Ph.D., M.S., M.Eng.
Clothing and Textiles—Ph.D., D.Ed., M.S., M.Ed.
Comparative Literature—Ph.D., M.A.
Computer Science—Ph.D., M.S.
Counselor Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Earth Sciences—M.Ed.
Economics—Ph.D., M.A.
Educational Administration—Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology—Ph.D., M.S.
Electrical Engineering—Ph.D., M.S., M.Eng.*
Elementary Education—Ph.D., D.Ed., M.S., M.Ed.
Engineering Acoustics—Ph.D., M.S.
Engineering Mechanics—Ph.D., M.S., M.Eng.
Engineering Science—M.Eng.*
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S., M.Agr.
Extension Education—M.Agr., M.Ed.
Family Economics and Home Management—Ph.D., D.Ed., M.S., M.Ed.
Food Service and Housing Administration—M.S., M.Ed.
Foods and Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Forestry—M.S., M.F.
French—Ph.D., D.Ed., M.A., M.Ed.
Fuel Technology—Ph.D., M.S.
General Engineering—M.Ed., M.Eng.
General Family Studies—Ph.D., D.Ed., M.S., M.Ed.
Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed., M.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Art (minor only)
Home Economics Education—Ph.D., D.Ed, M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—M.S., M.Eng.
Journalism—M.A.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.*
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Preparation—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S.
Music—M.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
Physiology—Ph.D., M.S.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., D.Ed., M.S.
Public Administration—M.P.A.
Recreation Education—M.S., M.Ed.
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
School Psychology—D.Ed., M.S., M.Ed.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
Solid State Technology—Ph.D., M.S.
Spanish—Ph.D., D.Ed., M.A., M.Ed.
Speech—Ph.D., D.Ed., M.A., M.Ed.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics—Ph.D., M.A., M.S.
Theatre Arts—M.A., M.F.A.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

The degrees listed above are the ones normally conferred in each of the designated major fields. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above fields in which a master's degree is conferred provided the field is appropriate to the preparation of teachers.

*Not offered on the University Park Campus.

Courses in Major and Minor Fields

AERONAUTICAL ENGINEERING

George F. Wislicenus, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Lumley, McCormick, and Wislicenus; Associate Professors Holl and Sevik; Assistant Professor Hoult.

Opportunities are available for graduate study in the following and related areas: modern fluid mechanics and physics, the interaction of fluids with solids, and the application of these disciplines to the design of devices and to the environment in which they operate. These topics are specifically included: cavitation, magnetohydrodynamics, rarified gas dynamics, the stability of laminar motions, turbulence, aero- and hydroelasticity, stability and control of vehicles, turbomachinery, V/STOL aircraft, high lift devices, and ground effect machines.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so.

AERONAUTICAL ENGINEERING (ARO E)

401a,b,c. Aeronautical Engineering Projects (2-12)
402. Aerospace Design (2)
407. Aerodynamics of V/STOL Aircraft (3)
410. Aircraft and Space Propulsion (3)
411. Aeroelasticity (3)
412. Aerodynamics of Viscous Fluids (3)
413. Stability and Control of Aircraft and Missiles (3)
415. Advanced Theoretical Fluid Dynamics (3-6)
416-417. Aerospace Undergraduate Thesis (2 each)
418. Aerospace Systems Engineering (3)
420. Principles of Flight Testing (3)

503. Electromagnetically and Chemically Active Flows (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. Aerodynamics of V/STOL Aircraft (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aro.E. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Perfect Fluid Theory A (3) Mathematical review, equations of motion

and general consequences, application of complex variables to two-dimensional flow, conformal representations, Stokes' stream function.

509. Perfect Fluid Theory B (3) Review of axisymmetric motion; two-dimensional vortex motions; motions with cylindrical, spherical geometry; Bessel, Legendre functions; vortex motions in space. Prerequisite: Aro.E. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory. Prandtl-Meyer flow, method of characteristics.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

518. Aircraft and Missile Dynamics (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, re-entry, stability and control, and automatic control. Prerequisite: Aro.E. 413.

520. Selected Topics in Aeronautical Engineering (1-12)

AGRICULTURAL ECONOMICS

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Barr, Becker, Bennett, Brandow, Butz, Frey, Hutton, McAlexander, Pasto, Pierce, Southworth, and Trotter; Associate Professor Stemberger.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

AGRICULTURAL ECONOMICS (AG EC)

407. Advanced Farm Management (3) *Mr. Hutton*
410. Agricultural Finance and Appraisal (3)
420. Agricultural Prices (3) *Mr. Bennett*
421. Land Economics (3) *Mr. Frey*
422. Land and Water Resource Policy (3)
426. (A.I. 426) Livestock Marketing (3) *Mr. Trotter*

450. International Agricultural Trade and Development (3) *Mr. Schutjer*
460. Industrial Organization in Food Processing and Distribution (3)
461. Decision-Making in Agricultural Marketing Firms (3)

500. Seminar in Agricultural Economics (1-6) Review of current literature and problems.

504. Seminar in Agricultural Policy (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy-making. Prerequisites: Ag.Ec. 420, Econ. 405. *Mr. Brandow*

505. Advanced Agricultural Statistics (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. Seminar in Farm Management (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

514. Survey Research Techniques in Agricultural Economics (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400.

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. *Mr. Brandow*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences.

527. Seminar in Applied Quantitative Methods (1-4)

534. Agricultural Production Economics (3) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. *Mr. McAlexander*

535. Seminar in Agricultural Marketing (2) *Mr. Southworth*

541. Economic Organization of Agriculture (3) Agriculture as a sector of the total economy; changes in markets, resources, internal structure, and income; interregional competition.

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods.

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use.

AGRICULTURAL EDUCATION

David R. McClay, *Head of the Department*
101 Agricultural Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

AGRICULTURAL EDUCATION

Graduate Faculty: Professors McClay and Stevens; Associate Professors Hoover, Anthony, and Love.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, and teacher education in agricultural education and related fields. Minors may be taken in any of the areas of agricultural science, technology, and business. Programs may include courses needed for certification in other fields of education.

AGRICULTURAL EDUCATION (AG ED)

418v. Survey of Vocational Education in Agriculture (1-3) *Mr. Hoover*
420v. Advanced Visual and Other Sensory Aids in Teaching Agriculture (1-6) *Mr. Anthony*
422v. Supervision of Vocational Education in Agriculture (1-3) *Mr. Anthony*
424v. Occupational Guidance in Agricultural Industry (1-4) *Mr. Hoover*
426v. Young and Adult Farmer Education in Vocational Agriculture (1-4) *Mr. Stevens*
434v. Agricultural Developments (1-6) *Mr. Love*

501v. History of Agricultural Education (1-3) Development of training for agricultural vocations; emphasis upon introduction of agricultural instruction into the high school program. *Mr. Hoover*

502v. Teaching Vocational Agriculture (1-3) Organization of instruction with respect to vocational objectives, methods of presentation, supervision of practice, pupil evaluation of goals, and follow-up. *Mr. Stevens*

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation. *Mr. Stevens*

504v. Agricultural Education Seminar (1 per term) *Mr. McClay and Staff*

508v. State and County Administration and Supervision of Agricultural Education (1-3) Organization and administration of state, county, township, and district systems of agricultural education; state and federal legislation. *Mr. McClay*

509v. Teacher Training in Agricultural Education (1-6) Construction of college curriculums, courses of study, and organization of college departments for training agricultural teachers. *Mr. McClay*

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education. *Mr. Stevens*

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems. *Mr. Stevens*

524v. Annual Plan of Work (1-3) Detailed study of the agricultural education needs of each student's community and outlining annual plans of work. *Mr. Hoover*

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, technique of teaching, and measurements of results of teaching. *Mr. McClay*

AGRICULTURAL ENGINEERING

Frank W. Peikert, *Head of the Department*
204 Agricultural Engineering Building

Degree Conferred: M.S.
Graduate Faculty: Professors Bartlett, Mohsenin, Peikert, and Stephenson; Associate Professors Aldrich and Kjelgaard.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; and rural sanitation and conservation engineering.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, solar poultry houses and plant growth structures for modified atmosphere, and a laboratory for research on mechanical and rheological properties of agricultural materials. This laboratory is equipped with an Instron testing machine with a complete line of accessories including an environmental chamber and the Instron Rheometer for research on rheology of foods and agricultural materials.

Prerequisite to major work is the completion of an undergraduate major in engineering.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Agricultural Structures (3)
404. Agricultural Machinery (3)
405. Agricultural Process Engineering (3)
406. Advanced Dairy Engineering (3)
407. Soil Water Engineering (3)
408. Instrumentation for Agricultural Production and Processing (3)
409. Agricultural Systems Engineering (3)
410. Agricultural Power (3)
420. Seminar (1)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop

practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY

Walter I. Thomas, *Head of the Department*
118 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Fortmann, Hunter, Kardos, Matelski, Raleigh, Richer, Thomas, and Washko; Associate Professors Baker, Cleveland, Duich, Harrington, Marriott, McKee, Pfeifer, and Starling; Assistant Professors Johnson and Marshall.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

AGRONOMY (AGRO)

411. Breeding of Field Crops (3) *Mr. Johnson*
416a. Soil Characterization and Classification—Lecture (4) *Mr. Pennock*
416b. Soil Characterization and Classificum—Practicum (1) *Mr. Pennock*
417. Forest Soils (3) *Mr. Pennock*
419. Soil Properties (4) *Mr. Baker*
422. Soil Conservation (3) *Mr. Kardos*
423. Pasture and Grassland Management (3) *Mr. Washko*
424. Fertilizer Technology (3) *Mr. Marriott*
425. Principles of Field Crop Production (3) *Mr. Pfeifer*
431. Soil Fertility and Management (3) *Mr. Marriott*
438. Principles of Weed Control (3) *Mr. Raleigh*
490. Agronomic Problems (1-6) *Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Bot. 441. Winter term, odd years.
Mr. Hunter

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practic-

um. Prerequisites: Agro. 419; Bioch. 417 or Chem. 23. Spring term, even years. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Phys. 215, Bioch. 425. Fall term, even years. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Bot. (Zool.) 422. Fall term, even years. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Bot. (Zool.) 422. Fall term, odd years. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. Fall term. *Mr. Starling*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. Winter term, odd years. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Bot. 441. Winter term, even years. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Bot. 441. Spring term, odd years. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 1, Chem. 13, G.Sc. 1. Winter term, even years. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. Winter term. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1-8 per term)

ANIMAL INDUSTRY

Thomas B. King
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S.

*Credits 1-6 per term.

Graduate Faculty: Professors Bortree and King; Associate Professor Gobble; Assistant Professor Sherritt.

A student may specialize in animal production and management, animal breeding, or meats. For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
405. Meat Animal Management (4)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Industry Seminar (1)
426. (Ag.Ec. 426) Livestock Marketing (3)
431. Advanced Meat Selection and Grading (2)

500. Seminar in Animal Industry (1-6)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

503. Problems in the Animal Industry (1-6) Literature review, research methods, and current research in problems relating to the animal industry.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

ANIMAL NUTRITION

Thomas B. King
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Barron, Bratzler, Cowan, Hartsook, and King; Associate Professor Hershberger; Assistant Professor Long.

The graduate program emphasizes nutrition, including energy metabolism, physiology of nutrition, and growth. For admission without deficiencies an applicant should have had at least one year's work each in general chemistry, organic chemistry, and physics; 3 credits in analytical chemistry; 3 credits in biochemistry; mathematics through integral calculus; and 9 credits in biology.

ANIMAL NUTRITION (A NTR)

401. Physiology of Nutrition (3) *Mr. Hartsook*
402. Energy and Protein Metabolism (3) *Mr. Hartsook*

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY

Donald P. Kent
Head of the Department of Sociology and Anthropology
240 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Baker, Carpenter, F. R. Matson, and Mook; Associate Professor Sanders; Assistant Professor Nydegger.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit.

Sociology may be chosen as a minor field by students majoring in anthropology. A thesis is required of all M.A. candidates in this field.

ANTHROPOLOGY (ANTHY)

401. Human Evolution (3)
402. Human Ecology (3)
420. Archaeology of the Near East (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
440. Ethnology of South America (3)
443. Ethnology of the Old World (3-6)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
450. Primitive Society (3)
451. Economic Anthropology (3)
455. Culture and Personality (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Applied Anthropology (3) Methods and results of studies in which anthropological theory was applied to current problems in human biology and culture.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, pop-

ulation composition, grouping patterns, individual and group interactional characteristics, communication.

530. Individual Study in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-6) Individual field work in any aspect of anthropology, supervised by staff of professorial rank.

562. Laboratory Methods in Anthropology (3-6) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

ARCHITECTURAL ENGINEERING

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.
Graduate Faculty: Professor Richardson; Associate Professor Albright; Assistant Professor Knott.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirements for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)
430. Architectural Engineering (3)
431. Architectural Engineering (3)
432. Architectural Engineering (4)
433. Architectural Engineering Thesis (2)
434. Architectural Engineering Thesis (2)
435. Architectural Engineering Thesis (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)
445. Architectural Engineering Seminar (1-6)
464. Advanced Architectural Illumination Systems Design (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.
Mr. Richardson and Staff

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar. *Mr. Richardson and Staff*

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems. Prerequisite: graduate standing.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers. Prerequisite: graduate standing.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE

Gregory Ain, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.
Graduate Faculty: Professors Ain and Hallock.

For admission, a degree of Bachelor of Architecture, Bachelor of Science in Architecture, or Bachelor of Fine Arts in a five-year curriculum in architecture is required.

ARCHITECTURE (ARCH)

401. Advanced Architectural Design Coordination (1)
402. Advanced Architectural Design Coordination (1)
403. Advanced Architectural Design Coordination (1)
411. Advanced Architectural Design (4)
412. Advanced Architectural Design and Thesis (3)
413. Advanced Architectural Design and Thesis (3)
415. City Planning (3)
443. Architectural Design Analysis (3)

501. Architectural Design (4-8) Problems in advanced planning and design, including study of group composition. Practicum and seminar.

502. Architectural Research (2-12) Prosecution of assigned problems under the guidance of an instructor.

ART

WIRTH V. McCOY, *Head of the Department*
210 Arts Building II

Degrees Conferred: M.A., M.F.A.
Graduate Faculty: Professors Heller, McCoy, and Zoretich; Associate Professors Altman, Cook, Fraenkel, Montenegro, Pappas, and Shobaken.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required.

Requirements for admission to the M.A. program include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

Requirements for admission to the M.F.A. program include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

ART (ART)

400. ADVANCED OIL PAINTING (3-12)
410. WATER-COLOR PAINTING: LANDSCAPE, STILL LIFE, AND FIGURE (3-9)
420. APPLIED DESIGN (3-9)
431. SCULPTURE (2-6)
440. PRINTMAKING (2-6)
480. ADVANCED CERAMICS (3)
490. LIFE DRAWING (3)

500. ART RESEARCH (2-6) Prosecution of assigned problems under the guidance of an instructor.

510. ADVANCED PAINTING (2-12)

531. ADVANCED SCULPTURE (2-12)

540. ADVANCED PRINTMAKING (2-12)

ART EDUCATION

EDWARD L. MATTIL, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Beittel and Mattil; Associate Professors Cataldo, Chomicky, Edmonston, and Pappas.

Graduate programs in this field prepare students for careers in public school art teaching, art supervision, college teaching, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include

work in art studio, art history, art education, education, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree.

ART EDUCATION (A ED)

404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Methods in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

534. Creative Art Activity for the Handicapped (3) Specific methods for development of creative art activity with the physically, mentally, emotionally, and socially handicapped; adjustive effect upon them. Prerequisite: 6 credits in art education or 6 in special education or 6 in psychology.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

598. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

599. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 level, including A.Ed. 598.

ART HISTORY

Winston R. Weisman, *Head of the Department*
229 Arts Building II

Degree Conferred: M.A.
Graduate Faculty: Professors Hyslop and Weisman; Assistant Professor Mauner.

For admission at least 18 credits of undergraduate work in art history are required. If an inadequacy exists, the student will be required to make up the deficiency without degree credit. Prior to graduation the candidate must demonstrate a working knowledge of at least one foreign language in his area of study.

A thesis is required of all M.A. candidates in this major.

ART HISTORY (ART H)

403. Studies in the Arts of the Middle Ages (3)
404. Theory and Form in Mannerist Art (3)
406. Movements in 19th Century European Art (3)
407. American Art of the Early Republic (3)
408. American Art from the Centennial to the Armory Show (3)
409. Movements in Contemporary Art (3-6)
410. Taste and Criticism in Art (3)
413. Problems in Art History (3-6 per term)
421. Contemporary Architecture (3)
448. History of Prints and Drawings (3)

502. Seminar in Medieval Art (3-6) Original research into problems dealing with the art of the middle ages.

503. Art History Research (3-6) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

504. Seminar in Renaissance Art (3-6) Investigations in the area of Renaissance art, centering around major masters and monuments.

505. Seminar in Baroque Art (3-6) Investigations in the area of Baroque art centering around major masters and monuments.

506. Seminar in Modern Art (3-6) Lectures, readings, reports, and discussions in the field of modern art.

507. Seminar in Modern Architecture (3) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

508. Seminar in American Art (3-6) Studies in the field of American art involving original research.

BIOCHEMISTRY

Thomas Wartik, *Acting Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Clagett, Mallette, Pritham, Sullivan, and Wartik; Associate Professor Shigley; Assistant Professors Loerch, Mumma, and R. Schraer.

Opportunities for research and graduate study are available in plant metabolism and photosynthesis, intermediary metabolism, nucleic acids, proteins, carbohydrates, lipides, enzymes, vitamins and nutrition, clinical chemistry, endocrinology, and pesticides.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

BIOCHEMISTRY (BIOCH)

401.	General Biochemistry (4)	*Mr. Clagett*
402.	General Biochemistry (4)	*Mr. Clagett*
404.	Food Chemistry (3-4)	
417.	Biochemical Methods of Analysis (4)	*Mr. Loerch*
425.	Biophysical Chemistry (4)	*Mr. Mumma*
426.	Biocolloids (3)	*Mr. Mallette*
436.	Physiological Chemistry (3)	*Mr. Pritham*
437.	Physiological Chemistry (3)	*Mr. Pritham*
438.	Clinical Methods (3)	*Mr. Pritham*
439.	Problems in Biochemistry (1-12)	

501. Enzymes (2) Investigations and theories concerning nature of enzymes, enzyme action, influence of chemical environment on enzyme action, and biological applications. Prerequisite: Bioch. 402 or 437. Fall term. *Mr. Clagett*

503. Biochemical Problems (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

505. Vitamins and Dietary Deficiency Diseases (2) Lectures, conferences, and assigned reading. Prerequisite: Bioch. 402 or 437. Fall term, odd years.

507. Seminar in Biochemistry (1 per term)

510. Proteins, Amino Acids, and Peptides (2) Organic, physical, and biological chemistry of the naturally occurring compounds of this group. Prerequisites: Bioch. 425; 402 or 437. Fall term. *Mr. Mallette*

511. Carbohydrates (2) Chemical constitution and properties of carbohydrates; their metabolism in plant and animal organisms. Prerequisite: Bioch. 402 or 437. Spring term. *Mr. Mumma*

512. Lipides (2) Investigations on biochemistry of fats and related substances. Winter term. *Mr. Shigley*

516. Chemistry of the Pesticides (2) Lectures and assigned readings on the chemistry of insecticides, fungicides, herbicides, rodenticides, and related materials. Prerequisites: Chem. 31; Bioch. 402 or 437. Winter term, even years.

517. Endocrine Secretions (2) Chemistry of hormones and their physiological significance. Prerequisite: Bioch. 402 or 437. Spring term, even years. *Mr. Pritham*

519. Intermediary Metabolism (3) Processes involved in the utilization of metabolites in plants and animals. Prerequisite: Bioch. 402. Spring term. *Mr. Mallette*

520. Biochemical Methods (3) Lectures and advanced laboratory on current

techniques pertaining particularly to research on proteins and enzymes. Prerequisite or concurrent: Bioch. 501, 510. Fall term. *Messrs. Clagett and Mallette*

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipides and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512. Winter term.
Messrs. Shigley and Mumma

BIOLOGICAL SCIENCE

Leon R. Kneebone, *Chairman of the Committee on Biological Science*
117 Buckhout Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biophysics, botany, entomology, genetics, microbiology, plant pathology, and zoology.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including at least one year of chemistry. In addition, 18 credits in education and related psychology are required for admission to the M.Ed. program. As many as 6 credits may be made up as undergraduate deficiencies after the candidate is admitted to the Graduate School.

The candidate for the M.Ed. degree must earn at least 24 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in educational foundations and a term paper are required.

The D.Ed. program, designed for secondary school and college science teachers, requires a minimum of 60 credits in natural science of which at least 45 must be in biological science. A minimum of 15 credits each is required in professional education and in thesis research. In addition, a reading knowledge of one foreign language is required.

BIOPHYSICS

Ernest C. Pollard, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professor Pollard; Associate Professors Deering, Ginoza, Person, H. Schraer, Smythe, and Strother; Assistant Professors Snipes and Taylor.

This program is designed for those interested in applying physical methods to the problems of living systems. A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. Opportunity to make up possible undergraduate deficiencies is provided in the program.

Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by the faculty. These include courses in physics, chemistry, biochemistry, zoology, botany, and microbiology.

BIOPHYSICS (BPHYS)

410. Special Topics (1-6)
473-474-475. Biophysics (2 each)

580. Biophysical Science (3) Theory of muscular contraction, heart action, and nerve conduction; X-ray analysis of proteins and nucleic acids; enzyme kinetics and thermodynamics.

581. Radiation Biophysics (2) The action of ultraviolet and ionizing radiation and of radioactive decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 474.

582. Biophysics of Nucleic Acids (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

583. Special Topics in Biophysics (1-6 per term)

584. Seminar in Biophysics (1 per term)

585. Electron Microscopy in Biological Science (3) Principles of electron microscopy and application of techniques for the study of the ultrastructure of biological materials. Prerequisite: any of the following—Bphys. 473, Zool. 437, Bot. 405, Micrb. 401.

BOTANY

Joseph G. O'Mara, *Head of the Department*
206 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Fergus, Grove, Grun, Kneebone, O'Mara, Wahl, and Wright; Associate Professors Hillson, Kovar, and Schein; Assistant Professors Bell, Hamilton, and Pursell.

Programs are offered in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics.
See also "Plant Pathology" and "Genetics."

BOTANY (BOT)

400.	Comparative Plant Morphology (4)	*Mr. Hillson*
403.	Plant Biology for Teachers (3)	*Mr. Westerfeld*
404.	Plant Biology for Teachers (3)	*Mr. Westerfeld*
405.	(Zool. 405) General Cytology (3)	*Mr. Grun*
407.	Plant Anatomy (3)	*Mr. Hillson*
414.	Taxonomy of Vascular Plants (3)	*Mr. Wahl*
419.	Mycology (3)	*Mr. Fergus*
421.	Botanical Technique (3)	*Mr. Pursell*
422.	(Zool. 422) Advanced Genetics (3)	*Messrs. Wright and Grun*
441.	Plant Physiology (3)	*Mr. Bell*
442.	Plant Physiology (3)	*Mr. Bell*
443.	Plant Physiology (3)	*Mr. Bell*
450.	Plant Autecology (3)	
451.	Plant Synecology (3)	

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Winter term. *Mr. Bell*

501. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years. *Mr. Fergus*

505. (Zool. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Bot. (Zool.) 405 or 422. Spring term, odd years. *Mr. Grun*

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Bot. 407. Spring term, even years. *Mr. Hillson*

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration, and catabolism. Prerequisite: Bot. 442. Fall term. *Mr. Hamilton*

512. Advanced Plant Physiology (3) Continuation of Bot. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Bot. 442. Winter term. *Mr. Hamilton*

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years. *Mr. Kovar*

518. Special Problems (1-12) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

521. Medical and Industrial Mycology (3) Structure, life histories, classification, and techniques of study of the fungi pathogenic to man and of fungi important in industry. Fall term, odd years. *Mr. Fergus*

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Bot. 419. Winter term, even years. *Mr. Fergus*

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Bot. 419. Spring term, even years. *Mr. Fergus*

524. (Zool. 524) Seminar in Genetics (1 per term) *Messrs. Wright and Grun*

528. (Zool. 528) Population Genetics (3) Factors affecting gene frequency, genotype frequency, genotype-environmental interaction, and genetic relationship in natural and artificial populations. Winter term, even years.

533. (Zool. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years. *Mr. Grove*

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seed and fruit development. Winter term, even years. *Mr. Grove*

537. (Sec.Ed. 537, Zool. 537) Workshop in the Biological Sciences (3)

Projects designed for teachers of biology in the secondary schools. Summer term only.

538. Botany Seminar (1 per term) Presentation and discussion of selected topics.

539. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years. *Mr. Pursell*

540. Algology (4) Comparative morphology, taxonomy, and ecology of fresh water and marine algae; culturing, collection, preservation techniques. Prerequisite: Bot. 421. Spring term, odd years. *Mr. Hillson*

BUSINESS ADMINISTRATION

William L. Ferrara
In Charge of Graduate Programs in Business Administration
122 Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty: Professors Bradley, Carzo, Cook, Day, Ferrara, Greenlaw, Kelley, Kniffin, McKinley, G. K. Nelson, Pashek, Richards, Rigby, Saylor, Schrader, Strong, Waters, and Wherry; Associate Professors Babione, Beik, Clewett, Coyle, Gotterer, Hammond, Phalan, Philips, and Williams; Assistant Professors Bennett, Cramer, Keister, Millman, Mock, Shilling, and Yanouzas.

The M.B.A. program is designed for those desiring professional education in business administration, regardless of their undergraduate background, in preparation for a career in either business or teaching. An applicant with little or no training in business administration may be admitted to the M.B.A. program and may schedule necessary preparatory courses while pursuing the graduate program. Three credits are required as preparatory courses in each of the following: accounting, business law, business statistics, economics, finance, management, and marketing.

The M.S. and Ph.D. degrees with a major in business administration are designed for those interested primarily in research and teaching.

For admission to these programs, a minimum of 18 acceptable undergraduate credits in the fields of accounting, commerce, economics, and business statistics—including at least 6 in economics and 3 in business statistics—is required. An applicant may be admitted with slight specific deficiencies which must be made up without degree credit.

Students completing master's degree programs in business administration must, either as an undergraduate or as a graduate student, complete the equivalent of basic instruction in the fields of economics, accounting, statistics, business law or legal environment of business, business finance, marketing, and management.

Applicants for the various graduate programs in business administration are required to take the Admission Test for Graduate Study in Business given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. The test is given at University Park and at numerous locations in most states and foreign countries in November, February, April, and July. For dates and locations see the *Bulletin of Information,* Admission Test for Graduate Study in Business, published by the Educational Testing Service, Princeton, New Jersey. Applicants should read the bulletin carefully. All arrangements for taking the test must be made directly with the Educational Testing Service.

BUSINESS ADMINISTRATION

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Auditing Concepts and Techniques (3)
404. Managerial Accounting (3)
406. Advanced Federal Tax Accounting (3)
407. Contemporary Issues in Accounting (3)
409. Machine and Electronic Accounting Methods (3)

500. Accounting Seminar (3-6)

504. Seminar in Managerial Accounting (3-6)

511. Interpretation of Account Data (3)

520. Problems in Accounting (3-6) Planned individual projects involving library, laboratory, or field work.

BUSINESS ADMINISTRATION (B A)

462. Problems in Trade and Transportation (3)

503. Seminar in Public Utilities (3)

517. International Business Practices (3) Practices of exporters and importers dealing in commodities traded in world markets under competition, monopoly, or governmental control. Prerequisite: B.A. 162.

540. Business Administration Theory and Practice (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

552. Business Research Methods (3) Research methods applicable to business problems with emphasis on means of obtaining data and the logic underlying research design.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administration.

BUSINESS LOGISTICS (B LOG)

410. Transportation and Public Policy (3)
412. Transportation Decision Techniques (3)

504. Problems in Business Logistics (3-6) Planned individual projects involving library, laboratory, or field work.

538. Transportation and Physical Distribution (3) Control of the movement

of goods; coordination of supply and demand in creation and maximization of time and place utility.

565. Seminar in Business Logistics (3-6)

BUSINESS STATISTICS (B S)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

FINANCE (FIN)

406. Investment Valuation and Management (3)
408. Credit Institutions (3)

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision-making.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. Estate Planning (3)

500. Insurance Theory and Practice (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

510. Risk Management (3) Analysis of managerial problems and responsibility for risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

MANAGEMENT (MGMT)

430. Administrative Management (3)
435. Cases in Public Relations (3)

510. Operations Management (3) Integration and application of decision-making to operational and policy problems within the business firm.

520. Organization Theory (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

522. Personnel Management (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

530. Seminar in Management (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

MARKETING (MKTG)

410. International Marketing (3)
423. Sales Management (3)
424. Marketing Research (3)
427. Advanced Retailing (3)

504. Problems in Marketing (3-6) Planned individual projects involving library, laboratory, or field work.

523. Seminar in Marketing (3-6) Research in modern marketing trends.

534. Marketing Management (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

BUSINESS EDUCATION

F. Wayne House
In Charge of Graduate Programs in Business Education
243 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

This program provides advanced preparation for teachers of business subjects for secondary schools and colleges. The subject-matter areas encompass secretarial, accounting, retailing, clerical, and general business sequences. The program may be adapted for the preparation of supervisors of business education.

A minimum of 18 acceptable undergraduate credits in education and psychology plus a minimum of 30 credits in business and business education subjects are required for admission.

All candidates specializing in business education are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanities.

BUSINESS EDUCATION (BUS ED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

511. Internship in Business Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CERAMIC TECHNOLOGY

Floyd A. Hummel, *Head of the Department*
214 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Buessem, Hummel, Weyl, and Williamson; Associate Professors Rindone and Stubican; Assistant Professor McKinstry.

The background for admission is a bachelor's degree in ceramics or in one of the related physical sciences. A knowledge of differential and integral calculus is required together with adequate physics and chemistry.

In view of the wide field covered by ceramic technology, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass technology. This makes it easily possible for students whose major subject for the bachelor's or master's degree has been either physics or chemistry to take appropriate graduate studies in ceramic technology.

Special facilities exist for research in the areas of clay mineralogy, phase equilibria, mineral synthesis, mechanical properties, ferrite and ferroelectric studies, glass technology, and high temperature reaction kinetics.

CERAMIC TECHNOLOGY (CER T)

400.	(Min. 400) Nonmetallic Crystal Chemistry (2)	*Mr. Brindley*
402.	Principles of Ceramic Engineering (3)	*Mr. Williamson*
404.	Ceramic Seminar (1)	*Mr. Hummel*
405.	Ceramic Research and Design (1)	
406.	Rheology and Fluid Properties of Ceramic Systems (2)	*Mr. Williamson*
407.	Ceramic Materials Laboratory (2)	*Mr. Williamson*
408.	Heat Treatment of Ceramic Materials (1)	*Mr. Stubican*
409.	Heat Treatment Laboratory (2)	*Mr. Stubican*
410.	Phase Relations in Ceramic Systems (3)	*Mr. Hummel*
411.	Principles of Ceramic Processes (2)	*Mr. Buessem*
412.	Surface Chemistry of Ceramic Materials (1)	*Mr. Weyl*

414. Principles of Ceramic Technology (2-3) *Mr. Hummel*
415. Principles of Glass Technology (3-4) *Mr. Rindone*
420. Refractories (2-3) *Mr. Stubican*
425. Ceramic Research and Design (2)
430. Electroceramics (2-3) *Mr. Buessem*

500. Seminar in Ceramic Technology (1-2 per term) Current developments in ceramic technology and related fields. Required of all graduate students in ceramic technology. *Mr. Hummel and Staff*

501. Colloidal Behavior of Clays and Muds (2-4) Colloidal properties of ceramic clays, glazes, drilling muds, filtering and bleaching clays, and kindred systems. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Technology (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452.

506. Mechanical Properties of Ceramic Materials (2-3) Experimental stress-strain-time relations in elasticity, anelasticity, plasticity, and rupture; theory of strength and control. *Mr. Buessem*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Buessem*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. Chemical Aspects of the Constitution of Glass (1-3 per term) Historical development, properties, and atomistic interpretation of changes of properties with compositions, temperature, and past history. *Mr. Weyl*

512. Physical Aspects of the Constitution of Glass (1-3) Atomic structure of glass, its relation to physical properties; rheology; glass as a liquid. *Mr. Rindone*

515. Special Problems in Ceramic Technology (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Technology (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Mr. Brindley*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in ceramic technology studies are listed under Mineral Sciences. The subject of color in glasses is treated in Min. 521.*

CHEMICAL ENGINEERING

MERRELL R. FENSKE, *Head of the Department*
131 Chemical Engineering Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Braun, Carnahan, Fenske, Jones, Klaus, McCormick, and Quiggle; Associate Professor Hersh; Assistant Professors Engel and Kabel.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, unit operations, unit processes, nuclear chemical engineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. The facilities for instruction and research in chemical engineering and petroleum chemistry include those of the Petroleum Refining Laboratory.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit.

Thesis research for the M.S. and Ph.D. degrees in chemistry may be done in the Department of Chemical Engineering.

CHEMICAL ENGINEERING (CH E)

404.	CHEMICAL PLANT DESIGN (3)	*Mr. Engel*
405.	THERMODYNAMICS FOR CHEMICAL ENGINEERS (3)	*Mr. Snyder*
406.	CHEMICAL ENGINEERING PROBLEMS (3)	*Messrs. Engel and Snyder*
410.	CHEMICAL ENGINEERING PRINCIPLES (3)	*Messrs. Carnahan and Kabel*
411.	CHEMICAL ENGINEERING PRINCIPLES (3)	*Messrs. Carnahan and Kabel*
412.	CHEMICAL ENGINEERING PRINCIPLES (3)	*Messrs. Carnahan and Kabel*
420.	CRYOGENIC ENGINEERING (3)	*Mr. Fritz*
422.	PETROLEUM PROCESSES AND PRODUCTS (2)	*Mr. Peiffer*
430.	NUCLEAR CHEMICAL ENGINEERING (3)	
435.	CHEMICAL REACTION KINETICS (3)	*Mr. Kabel*
440.	CHEMICAL ENGINEERING MATERIALS (3)	*Mr. Engel*
445.	CHEMICAL ENGINEERING RESEARCH (1-5)	
450.	PROCESS DYNAMICS (3)	*Mr. Snyder*
460.	CHEMICAL ENGINEERING (4)	*Mr. Daubert*

500. SEMINAR IN CHEMICAL ENGINEERING (1) Required of all graduate students.

505. SPECIAL TOPICS IN CHEMICAL ENGINEERING (2-12) Intensive study in the various specialized fields of chemical engineering.

515. DISTILLATION (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

520. EXTRACTION PROCESSES (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. MASS TRANSFER (3) Problem course on developments in diffusion, fluid dynamics, and phase equilibrium.

524. CHEMICAL ENGINEERING, APPLICATION OF THERMODYNAMICS (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

530. HEAT TRANSFER IN NUCLEAR REACTORS (3) Fluid flow, heat transfer, and

design problems in nuclear reactor systems.

535. Applied Reaction Kinetics (3) Basic principles of chemical kinetics, simultaneous heat and mass transfer, and prediction of rates; their application to reactor design.

CHEMISTRY

Thomas Wartik, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S., M.Ed.
Graduate Faculty: Professors Aston, Deno, Dixon, Fritz, Hutchison, Jordan, Lampe, Miller, Noll, Oakwood, Quiggle, Seward, Skell, Smith, Wartik, and Zook; Associate Professors Ascah, Bernheim, Goodman, Haas, Haim, Hayes, Hisatsune, Jones, Olofson, Richey, Schempf, Shamma, and Steele; Assistant Professors Adams, Lotz, Matwiyoff, and Rosenblatt.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent and the computer, cryogenic, petroleum, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at 1 p.m. at a departmental colloquium.

Students entering programs leading to the M.S. and Ph.D. degrees should have had training which includes at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is required, and a reading knowledge of at least one foreign language, preferably German, is expected.

The program leading to the M.Ed. degree is designed primarily for science teachers in secondary schools. Previous training should include a total of 18 credits in chemistry, mathematics through integral calculus, 6 credits in physics, and 18 credits in education and related psychology.

Prior to scheduling their first term program, new students will take examinations in the four areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. Chemical Literature (1)
401. Seminar (1)
405. Nuclear and Radiochemistry (3)
410. Advanced Inorganic Chemistry (4)
*421-422. Analytical Chemistry (4 each)
426. Instrumental Methods of Analysis (3-5)
435. Organic Preparations and Laboratory Methods (3-5)
437. Qualitative Organic Analysis (3)
439. Advanced Organic Chemistry (3)
448. Colloid Chemistry (3)
*451-452. Physical Chemistry (3 each)
453. Advanced Physical Chemistry (3)
454. Advanced Physical Chemistry (3)

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

455. Physical Chemistry of High Polymers (3)
*457-458. Experimental Physical Chemistry (1 each)
459. Experimental Physical Chemistry (1)
470. Chemical Microscopy (3)
471. Special Topics in Chemical Microscopy (2-6)
472. Quantitative Organic Microanalysis (3)
477. Chemical Photomicrography (3)
489. Introduction to Chemical Research (1-10)
†490. Organic Chemistry for Teachers (4)
†492. Advanced General Chemistry for Teachers (3)
†493. Selected Topics in Chemistry for Teachers (3-12)
†494. Chemical Demonstrations for Teachers (3)

500. Seminar in Inorganic Chemistry (1 per term)

501. Seminar in Physical Chemistry (1 per term)

502. Seminar in Organic Chemistry (1 per term)

503. Seminar in Analytical Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Separative and determinative processes in analytical chemistry.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12)

534. Theoretical Organic Chemistry (3) Modern theories of structure; resonance; interpretation of physical properties; theory of rates; equilibrium properties. *Mr. Aston*

535-536. Organic Chemistry (3 each) Adapted to the needs of those doing research work in organic chemistry.

538. Organic Chemistry (3) Survey of organic chemistry arranged primarily for graduate students majoring in fields other than organic chemistry.

542. Colloids (3) The physics and chemistry of surfaces and their resulting colloid properties; methods of preparing colloids. *Mr. Smith*

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Chemical Thermodynamics and Introductory Statistical Mechanics (3) Continuation of Chem. 544 including the calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisite: Chem. 544.

546. Quantum Chemistry (3) Calculation of electronic properties of atoms and molecules by wave mechanical methods including molecular orbital theory. Prerequisite: Chem. 565.

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.
†Candidates for the M.Ed. degree.

547. Statistical Mechanics (3) Properties of matter at equilibrium, develope on the basis of energy levels of molecules and statistical mechanical theory. Pr requisite: Chem. 565.

560. Topics in Physical Chemistry (3-12)

561. Chemical Principles (3) Mathematical treatment of the classical principl of chemistry; their application to problems. Required of all graduate student Prerequisites: Chem. 452, Math. 44, Phys. 204. A course in organic chemistry recommended.

563. Chemical Kinetics (3) Theory and measurement of the rates of chemic reactions; the mechanism of chemical reactions.

564. Chemical Kinetics (3) Continuation of Chem. 563 including theory an measurement of photochemical reactions.

565. Atomic and Molecular Structure (3) Introduction to modern theoretic chemistry: chemical bonds and molecular spectra.

567. Advanced Theoretical Chemistry (3) Modern and current theories of th properties of chemical substances and their applications to chemical problems; th construction of chemical theory.

581. Experimental Methods in Petroleum Chemistry (1-12)

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS

Joseph H. Britton, *Head of the Department*
105E Home Economics South

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Britton, Harms, Morgan, and Smith; Associate Pr fessors Broderick and de Lissovoy.

Students may specialize in the guidance and development of children, relationshi among various members of the family, problems of all stages of the family cycl nursery school education, education for home and family living in the schools, parent education, and work with children and families in community agencies.

The entering student should have had at least 6 credits in the physical and biolog cal sciences, 12 in the social sciences (which must include a basic course in sociolog and one in psychology), and 6 in child development and family relationships. Stu dents who are otherwise qualified but who lack some of these credits may be admitte and permitted to make up the deficiency credits along with a graduate program.

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CD FR)

415. Child Development and Family Relationships for Secondary Schools (3
418. Family Relationships (3) *Mr. Broderic*
429. Advanced Child Development (3) *Mr. de Lissov*
430. Teaching in Nursery School (1-6) *Mrs. Hu*
441. Nursery School Organization (3) *Mrs. Hu*
445. (Psy. 445) Development Throughout Adulthood (3) *Mr. Britto*
481. Educational Methods with Preschool Children (3) *Mrs. Hu*

500. Nonthesis Research (1-6)

508. Parental Education (3) Discussion and use of methods, experiences, and programs which can be used effectively to help parents in dealing with problems of parent-child relationships. *Miss Morgan*

515. The Teaching of Child Development and Family Relationships (3) Methods of selection and presentation of subject matter basic to understanding the development of children. *Miss Morgan*

529. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics. *Miss Harms*

530. Problems in Child Development and Family Relationships (1-6) Problems involving individual research in library, laboratory, or field projects.

536. (Psy. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

545. The Family in Its Community (3) Cultural influences on family relationships; how the family orients its members to community living and group participation. *Mr. Broderick*

546. Seminar in Family Relationships (1-6) Reading, reports, and discussion of recent research in relationship aspects of family living; particular attention to studies of roles, crises, and adjustments within the family setting. *Mr. Broderick*

548. Survey of Research on Sexual Behavior (3) Survey and evaluation of the contributions to the studies of sex by H. Ellis, Freud, Malinowski, Terman, Kinsey, and others. Prerequisites: 12 credits at the 400 and 500 level in child development and family relationships, psychology, sociology, or anthropology; 3 credits in statistics.

549. (Psy. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

CIVIL ENGINEERING

Benjamin A. Whisler, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.
Graduate Faculty: Professors Brielmaier, Gotolski, Kountz, Nesbitt, Perez, Shulits, Underwood, and Whisler; Associate Professors Barnoff, Blue, and Larson.

The entering student should be a graduate in civil engineering from an accredited college of engineering. Students may specialize in structures, hydraulics, transportation engineering, surveying, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.
See also "Sanitary Engineering."

CIVIL ENGINEERING (C E)

400. Seminar (1-3)

401. Civil Engineering Projects (2-12)
421. Highways and Streets (3)
423. Highway Safety and Traffic Control (3)
424. Civil Engineering Materials (3)
431. Civil Engineering Construction (3)
446. Advanced Soil Mechanics (3)
447. Advanced Structural Analysis (3)
448. Advanced Structural Design (3)
462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control (3)

500. Seminar in Civil Engineering (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

501. Civil Engineering Projects (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

521. Transport Planning and Design (2-6) Planning and design of transportation facilities; basic principles and engineering techniques applied to airways, highways, pipe lines, railways, waterways.

524. Advanced Problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

540. Advanced Structural Analysis (2-4) Geometry of flexure, deflections; analysis of continuous beams, rigid frames, arches; influence lines. Prerequisite: C.E. 46.

541. Advanced Structural Analysis (2-4) Truss deflection; trusses with redundant members, continuous trusses, framed arches; influence lines; secondary stresses; wind stresses; space framework; suspension bridges. Prerequisite: C.E. 46.

542. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

544. Advanced Structural Design (2-4) Plain and reinforced concrete design as applied to buildings, bridges, retaining walls, domes, tanks, and dams; prestressed concrete. Prerequisite: C.E. 448.

545. Advanced Structural Design (2-4) Structural steel design as applied to riveted and welded girders, trusses, rigid frames, wind connections; timber design. Prerequisite: C.E. 41.

547. Advanced Structural Theory (3-6) Prestressed concrete, arches, suspension bridges, concrete dams, thin shells, and other current topics. Prerequisite: C.E. 447.

550. Engineering Construction (2-4) Construction methods applied to foundations, buildings, bridges, and other civil engineering construction work. Prerequisites: C.E. 41, 42.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fluids (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Advanced Problems in Sanitary Engineering (3-10) Investigations, analyses, and reports on current topics in sanitary engineering.

574. Analytical Evaluations in Sanitary Engineering (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Sewage Treatment Plant Design (1-6) Design of works for treatment of sewage or industrial wastes. Prerequisite: C.E. 71.

578. Industrial Hygiene (3) Principles of control of industrial toxics and the protection of the worker and the community.

CLOTHING AND TEXTILES

Ruth W. Ayres, *Head of the Department*
120A Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professor Ayres; Associate Professors Densmore and Tesi.

Work may be taken with major emphasis in the textile area, which stresses the background natural sciences, or in the clothing area, which stresses the background social sciences. Candidates are accepted who have a strong foundation and a good record in any of the following: home economics, chemistry, sociology, economics, or psychology.

CLOTHING AND TEXTILES (CL TX)

400. Special Problems in Clothing and Textiles (1-6)
402. Fundamental Principles of Tailoring Construction (3) *Mrs. Larson*
403. Creative Pattern Making (3) *Mrs. Larson*
404. Draping (3) *Mrs. Larson*
406. Fashion Promotion (3) *Mr. Tesi*
407. The Textile and Clothing Industry (3) *Mr. Tesi*
408. Intermediate Textiles (3) *Miss Densmore*

410. Clothing for the Family (3) *Mrs. Adam*
411. Advanced Clothing Construction (3) *Mrs. Larson*

500. Nonthesis Research (1-6)

501. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

506. Clothing Behavior (3) Analysis and interpretation of clothing behavio through the application of theories selected from the behavioral sciences.

507. Problems in Relation to Clothing Consumption (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries. *Mr. Tes*

508. Special Problems in Clothing and Textiles (1-6) Individual directed study, investigation, and practice in selected phases of textiles and clothing.

509. Seminar in Clothing and Textiles (1-6)

510. Research Methods and Evaluation in Clothing and Textiles (1-6) *Miss Densmor*

511. Current Developments in Clothing and Textiles (1-6) *Miss Ayre*

512. History of Clothing and Clothing Construction (3)

513. Advanced Textile Technology (6) *Miss Densmor*

COMPARATIVE LITERATURE

Philip A. Shelley
Chairman of the Committee on Comparative Literature
203 Schwab Auditorium

Degrees Conferred: Ph.D., M.A.

Programs are arranged through a meaningful selection of courses offered by th several departments of languages and literatures, both ancient and modern, as wel as of those specifically in the category of comparative literature. More than a mini mum knowledge of foreign languages is required.

A thesis is required of all M.A. candidates in this major.

COMPARATIVE LITERATURE (C LIT)

443. (Ger. 443) Literary Relations of Germany with England and Americ (3-9) *Mr. Shelle*
470. Old Masters of the Modern Novel (3) *Mr. Mors*
480. Introduction to Folklore (3) *Mr. Bayar*

500. Seminar in Comparative Literature (3-6)

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tale surveyed and compared with respect to backgrounds, development, themes, an characteristics. *Mr. Bayar*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. Morse*

COMPUTER SCIENCE

Preston C. Hammer, *Head of the Department*
426 McAllister Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Hammer and Selfridge; Associate Professors Laird and McCammon; Assistant Professors Barnes and Wegner.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including foundations of computer science, languages and programming systems, numerical analysis, nonnumeric procedures, and heuristic methods. The Computation Center has modern digital equipment and systems available for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent of Cmp.Sc. 401 and at least three of the five following: (1) Math. 441 or 481, (2) Cmp.Sc. 410, (3) Math. 453, (4) Math. 454, (5) Math. 428 or E.E. 471. The remainder of these five must be completed for the M.S. or Ph.D.

The M.S. candidate must satisfactorily complete (a) Cmp.Sc. 510 or 511 and (b) Cmp.Sc. 530 or 540, in addition to the other requirements of the Graduate School.

Admission as a candidate for the Ph.D. normally requires completion of course requirements for the M.S. and a background equivalent to an undergraduate major in mathematics.

The Ph.D. candidate must pass three written examinations: one in a field of specialization, one in a field of mathematics, and the third in a related approved by the doctoral committee.

COMPUTER SCIENCE (CMP SC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
410. Introduction to Computer Systems (3)
453. (Math. 453) Numerical Computations (3)
454. (Math. 454) Matrix Computations (3)
490. Special Topics in Computer Science (1-9)

500. Theory of Automata (3) Foundations of computer science with emphasis on computability; logic and structure of finite automata. Prerequisites: Cmp.Sc. 401, 402, or 403; 3 credits in logic at the 400 level.

510. Structure of Artificial Languages (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguistics. Prerequisites: 3 credits in logic or logical design at the 400 level; Cmp.Sc. 401, 402, or 403.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multi-access systems, multiprogramming, multiprocessing. Prerequisite: Cmp.Sc. 410.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 401, 402, or 403.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 401, 402, or 403.

590. Seminar in Computer Science (1-3) Topics from current research.

591. Special Topics in Computer Science (2-6)

COUNSELOR EDUCATION

Arthur M. Wellington
In Charge of Graduate Programs in Counselor Education
114 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Hudson and Wellington; Associate Professor Hylbert; Assistant Professor Kelz.

Professional preparation programs are offered at the master's level for school counselors (elementary or secondary), college student personnel workers, and rehabilitation counselors. Doctoral programs prepare for pupil personnel administration, college student personnel administration, or supervision of rehabilitation.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits in economics, education, psychology, sociology, and physiology or anatomy with some credits in at least three of these areas.

Because school counselors need two years' experience as teachers, social workers, or professional counselors in order to be certified, the experience requirement must be met before receiving a degree. Prospective school counselors lacking such experience should plan to work for their degrees over a series of summers while acquiring requisite experience through the remainder of the year. Those wishing to become college student personnel workers must have a year of appropriate work experience in a college setting before receiving a degree. Prospective rehabilitation counselors are provided with an off-campus supervised internship as part of their professional preparation.

All Counselor Education degrees at Penn State are based, in addition to Graduate School requirements, on demonstrated counselor competencies.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

Courses in counselor education are listed under the offerings of the Department of Educational Services (see page 103). Additional courses are selected from other areas and departments.

DAIRY SCIENCE

Donald V. Josephson, *Head of the Department*
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Almquist, Cone, Josephson, Kesler, Patton, and Watrous; Associate Professors Flipse, Keeney, and McCarthy; Assistant Professor Amann.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipide metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, zoology, or agricultural economics.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

DAIRY SCIENCE (D SC)

405. Dairy Cattle Management (3) *Mr. Cloninger*
418. Dairy Survey (1) *Mr. Josephson*
421. Technical Control Problems (1-10) *Messrs. Watrous and Keeney*
427. Milk Secretion (3) *Mr. Kesler*
428. Dairy Production Problems (1-6)
431. Physiology of Reproduction in Farm Animals (3) *Messrs. Almquist and Amann*

501. Butter and Cheese (1-6) Manufacture and handling of butter and cheese. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Watrous*

502. Condensed Milk and Milk Powder (1-6) Condensing and drying of milk. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Keeney*

503. Public Milk Problems (1-6) Handling milk in modern plants. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Watrous*

504. Ice Cream Manufacture (1-6) Manufacture of ice cream, ices, and other frozen milk products. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Keeney*

505. Dairy Plant Economics (1-6) Economic factors involved in creamery operation and management. Prerequisite: D.Sc. 7. *Mr. Watrous*

507. Dairy Cattle Management (1-6) *Mr. Kesler and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

509. Testing Dairy Products (1-6) Constituents of dairy products. Prerequisites: Bioch. 404, Micrb. 8.

510. Dairy Cattle Feeding (1-6) Application of fundamental research in animal nutrition to the feeding of dairy cattle. Prerequisite: D.Sc. 1. *Mr. Kesler*

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Zool. 422, 3 credits in statistics. *Mr. Thoele*

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Mr. Josephson and Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. Flipse*

522. Research Procedures in Dairy Technology (3) Research problems and methods in dairy technology with major emphasis on dairy chemistry. Prerequisite: Bioch. 404. *Mr. Patton*

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

EARTH SCIENCES

E. Willard Miller
Chairman of the Committee on Earth Sciences
123 Mineral Industries Building

Degree Conferred: M.Ed.

This program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, meteorology, mineralogy, and soils.

The program prepares candidates to teach at least one field of the earth sciences, familiarizes them with at least two additional earth science subjects, and at the same time enables them to increase their competence in the physical sciences, the biological sciences, and mathematics.

The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

ECONOMICS

Grant N. Farr, *Head of the Department*
326 Boucke Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Budd, Coppock, Farr, Kaufman, Mares, Mason, Newman, Prybyla, Reede, Roose, Rozen, Saylor, and Stout; Associate Professors Iwand, Klein, Myers, Robinson, Sauerlender, and Shearer; Assistant Professors Riew and Stromsdorfer.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development; developed areas, economic development; underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, and statistics.

A thesis is required of all M.A. candidates in this major.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics.

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)
404. Current Economic Issues (3)
405. Advanced Economic Analysis (3)
412. Economics of Collective Bargaining (3)
413. Comparative Labor Movements (3)
415. Social Insurance (3)
418. Economics of Wages and Employment (3)
419. Case Studies in Labor-Management Relations (3)
423. State and Local Taxation (3)
429. Advanced Public Finance (3)
433. International Monetary Economics (3)
442. Monopoly, Competition, and Their Regulation (3)
450. The Business Cycle (3)
451. Advanced Money, Banking, and Fiscal Policy (3)
452. The Money Markets (3)
461. Economic Growth: Underdeveloped Areas (3)
462. Economic Growth: Theories of United States Development (3)
480. Mathematical Economics (3)
490. Measurement of the Economy (3)
491. Analysis of Linear Economic Models (3)
499. Foreign Study in Economics (2-6)

500. Economics Seminar (3-6)

506. Problems in Economics (3-6) Planned individual projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulations of the quantity theory; liquidity approach to monetary theory; current issues in monetary theory and policy.

510. Econometrics (3) Statistical estimation in mathematically formulated economic relationships.

512. Wage Determination (3) Development of wage and employment theory; structure of labor markets; impact of unions on income distribution, price level, and employment.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

516. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision-making and control.

572. Soviet and Other Centrally Planned Economies (3) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

EDUCATIONAL ADMINISTRATION

Walter J. DeLacy
In Charge of Graduate Programs in Educational Administration
303 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Davison, DeLacy, McAulay, McGarey, Miller, Remaley, and Willower; Associate Professor Bosch.

Professional preparation programs are offered at the master's level for elementary and secondary school principals and supervisors. Doctoral programs prepare for positions of supervising principal, assistant superintendent, and superintendent of schools.

Requirements for admission to a graduate program in educational administration include 18 approved undergraduate credits in education and psychology. Applicants for admission to the master's degree program are required to have had one year of teaching experience, or to be currently engaged in teaching. Two years of teaching experience are required for admission to the doctoral program.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600 or 610 thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term, unless approved by the candidate's committee, shall be considered automatic withdrawal.

Although candidates are required to specialize in a field of professional education, they are also encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

Courses in educational administration (Ed.Ser. 480 and 565 to 582 inclusive) are listed under the offerings of the Department of Educational Services. Additional courses may be selected from other areas and departments to meet the student's needs, including certification requirements.

DEPARTMENT OF EDUCATIONAL SERVICES—This department (Franklin A. Miller, *Head*, 204 Education and Psychology Center, Building II) offers graduate programs in counselor education, educational administration, and higher education. It also offers the following course sequences which are not graduate majors:

Adult Education	460, 575
History and Philosophy of Education	417-420, 516-523
Research, Seminars, and Projects	596-599
Safety Education	451-452
Special Education	425-431, 525-529

These courses carry graduate credit and, with the approval of the student's adviser, may be applied toward the requirements for an advanced degree in any major field.

EDUCATIONAL SERVICES (ED SER)

403. Guidance Principles and Practices (3)
404. Teaching and Group Guidance About Occupations (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
420. History of Modern European Education (3)

425. Education of Exceptional Children (2-3)
427. Education of the Mentally Retarded (2-3)
429. Education of the Mentally Gifted Child (1-3)
430. Practicum in the Education of Atypical Children (1-8)
431. Atypical Children and Educational Adjustments (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisites: Ed.Ser. 506, Ed.Psy. 451.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals.

505. Occupational and Educational Information (3) Occupational information for guidance purposes; educational information related to vocational choice and preparation. Prerequisite: Ed.Ser. 403.

506. Student Analysis Procedures for Counselors (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing.

507. Supervised Experience in Student Counseling (3) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Ed.Ser. 403.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Ed.Ser. 403.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Ed.Ser. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Ed.Ser. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisite: Ed.Ser. 511.

513. Supervision of Guidance Workers (3) Practical experience in supervising and evaluating work of counselors. Prerequisite: Ed.Ser. 507.

516. Social Foundations of Education (2-4) Social institutions and functions and their relationship to public education; analysis of the functions assignable to formal education. Prerequisites: El.Ed. 311 or Sec.Ed. 331; Ed.Psy. 14.

517. Advanced Philosophy of Education (2-4) Analysis of educational policy and practice for philosophic consistency and commitment; philosophical implication in selected educational literature.

518. Evolution of Educational Thought (2-3) Rise of formal educational philosophy from Plato to John Dewey; preliminary reference to Chinese, Hindu, Chaldean, Persian, Hebrew, and Egyptian theories.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina.

522. Comparative European Education (3) Educational policies and practices in school systems in western and central European nations. Prerequisite: Ed.Psy. 14.

523. Education in Russia, Asia, and the Middle East (2-3) Current educational activities in Soviet Russia and other eastern European countries; the Middle East, North Africa, and the Far East.

525. Internship in Special Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

527. Problems in the Education of the Mentally Retarded (1-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience; Ed.Ser. 425 or 577, and Ed.Ser. 427.

529. Problems in the Education of the Mentally Gifted (1-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience; Ed.Ser. 425 or 577, and Ed.Ser. 429.

545. Higher Education in the United States (2-3) Historical perspective and current status; development of functions and structures; issues in curriculum, admissions, government, administration, and finance.

546. The Principles of College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in Higher Education (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professional Education of Teachers (3) Development and present status of teacher education; objectives and standards; selection and guidance of students; personnel problems in relation to staff. Prerequisite: 6 credits in advanced courses in education and a course in educational psychology.

551. Student Personnel Programs in Higher Education (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

555. Seminar in Higher Education (1-6) Special topics in higher education.

565. Principles of School Supervision (2-3) Organization of supervision; planning the supervisory program; developing standards of teaching and learning; im-

provement of learning through tests and teacher rating. Prerequisites: 18 credits in education and 3 years' teaching experience.

566. The Elementary School Principal as Supervisor (2-3)

567. The Secondary School Principal as Supervisor (2-3) Improvement of instruction; improvement of teachers in service; evaluation of teaching procedures; methods of supervision; selection and use of textbooks. Prerequisite: three years' teaching experience.

568. The Elementary School Principal as Administrator (2-3) Duties of the elementary school principal in organizing and administering his school.

569. The Secondary School Principal as Administrator (2-4) Problems of schedule making, teachers' meetings, curriculum making and revision, organization of extra-curricular and guidance programs. Prerequisite: teaching experience.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

574. State and National Education Programs (2-3) Existing state and federal functions and relations to education; proposed programs. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes; torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

577. The Administration of Public School Education for Atypical Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal

organization. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience; Ed.Ser. 573.

580. Seminar in School Administration (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

581. Educational Survey Techniques (2-3) Methods for appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

596. Seminar in Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Education (1-6) Independent work in the study of topics in education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

599. Internship in Public School Research (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

EDUCATIONAL PSYCHOLOGY

William Rabinowitz, *Head of the Department*
311 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors DiVesta, French, Mitzel, Rabinowitz, VanOrmer, and Withall; Associate Professors Lathrop and Thevaos; Assistant Professors Snyder and Wodtke; Mr. Greenhill.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems, including programmed learning. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Special facilities include a research design laboratory, a laboratory for computer-based instruction, a self-instruction media laboratory, facilities for film production

and editing, and a closed-circuit television studio in Chambers Building used for both research and instruction. Facilities in other departments available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with an IBM 7074 Computer, is available for use in graduate student research.

Requirements for admission include a broad undergraduate background including some college mathematics, a minimum junior-senior scholastic average of B, and a satisfactory scholastic aptitude rating on either the Graduate Record Examination or the Miller Analogies Test. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one third of their graduate credits of "A" quality.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in two related areas (one being in this department). Typically, the doctoral program of study would include at least one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, instructional media, measurement, social or industrial psychology, clinical psychology, experimental psychology, and developmental psychology.

EDUCATIONAL PSYCHOLOGY (ED PSY)

400. Statistical Interpretation of Educational Research (2)
406. Applied Parametric and Nonparametric Statistics in Education (3)
407. Regression and Correlation Methods for Educational Data (2)
421. Learning Theories Applied to Educational Practice (3)
450. Principles of Measurement (3)
451. Appraisal and Interpretation of Standardized Group Tests (2)
475. Introduction to Educational Research (2)

506. Advanced Techniques for Analyzing Educational Experiments (2) Advanced techniques for research in education; analysis of covariance; repeated measures; randomized block designs; Latin square; and other experimental arrangements. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

520. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 421.

521. Concept-formation, Problem-solving, and Decision-making Processes in Schools (2) Study of paradigms and models of concept formation, problem-

solving strategies, choice-making, and judgment as related to complex verbal learning. Prerequisite: Ed.Psy. 520.

530. Theory and Research in Programmed Learning (3) Research and trends in programmed learning; preparation of short programmed sequences for experimental analysis. Prerequisites: Ed.Psy. 450 and 421, or Psy. 404.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

558. Scaling Educational and Psychological Measures (2) Unidimensional and multidimensional scaling models with emphasis on psychometric methods and brief attention to psychophysical methods. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

599. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING

Arthur H. Waynick, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus)

Graduate Faculty: Professors Hagen, Holt, Mentzer, Ross, Volz, and Waynick; Associate Professors El-Kareh, Ferraro, Marsh, and Nisbet; Assistant Professors Adams, Etzweiler, Hale, Lachs, Lee, Quinn, and Russo.

Course offerings and research facilities are available in the following areas: information theory, microwave theory and techniques, networks, computers (including digital, analog, and network analyzer), control, power conversion, servomechanisms, electron devices, dynamical machine analysis, power systems analysis, wave propagation, ionosphere research, and radio astronomy.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate course work in electrical circuits, machinery, and electronics.

ELECTRICAL ENGINEERING (E E)

421a,b,c,d. Electrical Engineering Problems (2-12)
425. Symmetrical Components (3)
426. Transistors (3)
428. Servomechanisms (3)

432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
438. Electromagnetic Theory and Radiating Systems (3)
439. Pulse Techniques (3)
441. Active Circuits (3)
450. Electrical Network Theory (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Digital Computers (3)

514. Quantum and Solid State Electrical Engineering (3) Electron theory of atoms and solid structures, as applied to electrical engineering concepts and devices. Prerequisite: Phys. 412.

520. Seminar (1) Required of all graduate students in electrical engineering. Conferences, reading, and presentation of technical papers.

521. Advanced Electrical Engineering Problems (2-12)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

526. Transistors and Active Circuits (3) Advanced semiconductor electronic theory, transistor circuit analysis, and applications. Prerequisite: E.E. 426.

528. Servomechanisms (3) Advanced treatment of transient and steady-state behavior of closed-cycle control systems with special attention to stability and design of stabilizing controllers. Prerequisite: E.E. 428.

532. Ultra-High-Frequency Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisite: E.E. 432 or 438.

535. Engineering Analysis (3) Engineering applications of complex variables, conformal mapping methods, and potential plotting; Laplace transform methods and stability criteria. Prerequisite: E.E. 435.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electrical and magnetic fields, using the Maxwell-Lorentz equations as applied to vector fields and special solutions for antennae, wave guides, and other engineering applications. Prerequisite: E.E. 438.

550. Passive Network Synthesis (3) Network synthesis using (a) realizability conditions; (b) image parameters, realization methods for two-terminal pair networks; rational fraction approximations; time domain synthesis. Prerequisites: E.E. 450, 535.

560. Information Theory (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; optimum filtering and prediction. Prerequisite: E.E. 45.

561. Information Theory (3) Mathematical measurement of information: information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 560.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 43 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ELEMENTARY EDUCATION

A. Madison Brewer, *Head of the Department*
150 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Bixby, Brewer, Corle, McAulay, and Russell; Associate Professors Alessandro, Alfke, Bosch, Coulter, Riedesel, and Zafforoni.

The graduate programs provide advanced professional preparation for kindergarten teachers, elementary school teachers, and curriculum specialists. For admission 18 credits in elementary education, including teaching experience, are required.

ELEMENTARY EDUCATION (EL ED)

401. Training in Nature for Camp Counselors (3)
426. Problems of Elementary School Arithmetic (2-3)
433. Teaching Social Studies in the Elementary Grades (2-3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (2-3)
444. Reading Disabilities (2-3)
445. (Sec.Ed. 445) Techniques in Remedial Reading (2-6)
449. Teaching Children's Literature (2-3)
453. Special Problems in the Teaching of Elementary School English (2-3)
461. Elementary Education (2-3)
467. Advanced Theory of Kindergarten (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities

in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

546. (Sec.Ed. 546) Seminar on Reading Instruction (3-6) Research, procedures, and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: El.Ed. 443 or Sec.Ed. 443.

557. Reading Clinic Practice: Remedial Procedures (1-9) Practicum in special classes for reading disabilities; corrective and remedial procedures; specific procedures for correction of various types of reading disabilities. Prerequisite: El.Ed. 444.

559. Reading Clinic Research (1-15) Prerequisites: El.Ed. 443 or Sec.Ed. 443; El.Ed. 444.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principals underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers: administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

594. Seminar in Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

ENGINEERING ACOUSTICS

Vernon M. Albers
Chairman of the Committee on Engineering Acoustics
227 Ordnance Research Laboratory

Degrees Conferred: Ph.D., M.S.

The aim of this program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by the several departments of science, engineering, and arts, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Ordnance Research Laboratory.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, or speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Course work should be so distributed that one area is covered in depth while a substantial number of courses are chosen from a combination of the other areas.

Courses specifically designed for this program are Engr. 511, Underwater Sound Propagation; Engr. 512, Sonar Engineering; and Engr. 513, Modern Acoustic Signal Processing.

ENGINEERING MECHANICS

ROBERT K. VIERCK, *Acting Head of the Department*
105 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Professors Davids, Hardenbergh, Hu, Vierck, and Wislicenus; Associate Professors Inman, Jaunzemis, Neubert, and Sharma; Assistant Professors Hayek, Kiusalaas, and Weitsman.

Graduate study is available in the following areas: (1) mechanics of rigid bodies including dynamics, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration; (5) fluid mechanics.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics.

ENGINEERING MECHANICS (E MCH)

400.	ADVANCED STRENGTH OF MATERIALS (3)	*Mr. Kiusalaas*
401.	ELEMENTS OF VIBRATIONS (3)	*Messrs. Vierck and Hayek*
402.	APPLIED AND EXPERIMENTAL STRESS ANALYSIS (3)	*Mr. Theocaris*
403.	MECHANICS OF THE SOLID STATE (4)	*Mr. Hu*
404.	RESEARCH IN ENGINEERING MECHANICS (1-6)	
407.	NUMERICAL METHODS OF ANALYSIS (3)	*Mr. Sharma*
408.	ELASTICITY AND ENGINEERING APPLICATIONS (3)	*Mr. Weitsman*
409.	ADVANCED MECHANICS (3)	*Mr. Hardenbergh*
410.	MECHANICS OF SPACE FLIGHT (3)	*Mr. Hardenbergh*
412.	EXPERIMENTAL METHODS IN VIBRATIONS (3)	*Mr. Neubert*
413.	PLASTIC ANALYSIS OF STRUCTURES (3)	*Mr. Hu*
414.	ELEMENTS OF MATERIAL SCIENCE (3)	*Mr. Inman*
421.	CONTINUUM MECHANICS (3)	*Mr. Jaunzemis*
422.	CONTINUUM MECHANICS (3)	*Mr. Jaunzemis*
446.	MECHANICS OF VISCOELASTIC MATERIALS (3)	*Mr. Sharma*

500. ADVANCED MECHANICS OF MATERIALS (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-

walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13.

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507.

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13.
Messrs. Hu and Weitsman

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to internal pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics.

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potentials; applications. Prerequisite: E.Mch. 540. *Messrs. Jaunzemis and Weitsman*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 44 or 431. *Messrs. Davids and Jaunzemis*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 44 or 431.
Messrs. Vierck and Neubert

523. Relaxation Methods (3) Relaxation methods compared to iteration and other numerical methods of analysis; application to elasticity, plasticity, stability, fluid flow, heat transfer, and related fields. Prerequisites: E.Mch. 13 or 111, Math. 44. *Messrs. Vierck and Sharma*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: Math. 451 or E.E. 435 or M.E. 452. *Mr. Davids*

Unit A (3) Basic concepts of tensors; matrices; numerical procedures; approximation; Fourier, Legendre, and other orthogonal series; applications; Bessel and other special functions.

Unit B (3) Basic solutions of Laplace, diffusion, wave equations; boundary-value

problems; Fourier, Laplace transforms; contour integration techniques; Caignard's, energy methods.

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical applications. Prerequisite: E.Mch. 522. *Mr. Neubert*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522.

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14.

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507.

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Mr. Jaunzemis*

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540 or 421. *Mr. Jaunzemis*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

ENGINEERING SCIENCE

John L. Lumley
Chairman of the Committee on Engineering Science
233 Hammond Building

Degree Conferred: M.Eng.

Programs leading to the degree of Master of Engineering with a major in engineering science are offered only at University Graduate Centers away from the main campus. The King of Prussia Graduate Center and the Susquehanna Valley Graduate Center are operating. Others are in various stages of planning. Details of the programs available in the various Centers may be obtained by writing directly to the persons in charge. See the inside front cover for the addresses.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest.

It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits of course work is required, of which at least 12 must be at the 500 level. A scholarly written report is also required.

A bachelor's degree in engineering or a closely allied field is required for admission.

ENGLISH

Henry W. Sams, *Head of the Department*
245 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Professors Bayard, Brady, Condee, Cramer, Davis, Euwema, Frank, Goldberg, Lewis, Meserole, Morse, Peck, Rubin, Sams, G. Smith, Sutherland, Weintraub, and Young; Associate Professors Austin, Bressler, Hansen, Jewkes, Oldsey, Reed, Reiss, and West; Assistant Professors Borklund and Wellwarth.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work.

A thesis is required of all M.A. candidates in this major.

ENGLISH (ENGL)

406. History of the English Language (3) *Messrs. Buckalew and Shedd, Miss DeWeese*
407. History of the English Language for Teachers (3) *Messrs. Buckalew and Shedd, Miss DeWeese*
408. Advanced College Grammar (3) *Miss McElwee*
411. Problems of Style (3)
412. The Writing of Fiction (3-6) *Messrs. Rubinstein, Rogers, and West*
413. Verse Writing (3-6) *Mr. Haag*
414. Biographical Writing (3) *Mr. Weintraub*
418. Advanced Technical Writing and Editing (3-6) *Messrs. Hoffman and Houp*
422. Masters of British Literature (3-6)
423. History of British Literature (3) *Mr. Steese*
424. Movements in British Literature (3)
432. Masters of American Literature (3-6) *Messrs. Bressler, Davis, and Staff*
433. History of American Literature (3) *Messrs. Sutherland and Gidez*
434. Movements in American Literature (3-6) *Messrs. Hansen, Meserole, and Staff*
435. The American Short Story (3) *Mr. Bressler*
437. American Poetry (3) *Messrs. Rubin and Hansen*

438. American Drama (3) *Mr. Wellwarth*
441. Poetry and Prose of the Early 17th Century (3) *Mr. Condee*
442. Poetry and Prose of the Late 17th Century (3) *Mr. Brady*
443. Jacobean and Caroline Drama (3) *Messrs. Jewkes, Reed, and Smith*
444. Shakespeare (3) *Messrs. Jewkes, Reed, and Smith*
445. Chaucer (3) *Messrs. Frank and Reiss*
446. Milton (3) *Mr. Condee*
447. Poetry and Prose of the 16th Century (3) *Messrs. Reed and Smith*
448. English Drama Before Shakespeare (3) *Mr. Jewkes*
449. Shakespeare (3) *Messrs. Jewkes, Reed, and Smith*
451. Poetry and Prose of the Early 18th Century (3) *Mr. Sams*
452. Poetry and Prose of the Late 18th Century (3) *Mr. Brady*
455. The Novel in England to Jane Austen (3) *Mr. Brady*
458. The Drama from Dryden to Sheridan (3) *Mr. Rogers*
461. British Prose of the 19th Century (3) *Mr. Cramer and Miss Austin*
462. Wordsworth and Coleridge (3) *Mr. Cramer and Miss Austin*
463. Byron, Shelley, and Keats (3) *Mr. Peck*
465. Victorian Novel (3) *Miss Austin*
466. The American Novel to 1900 (3) *Messrs. Young and Oldsey*
467. Victorian Poetry (3) *Mr. Cramer*
470. Literature of the British Commonwealth (3) *Mr. Sutherland*
475. Modern British Fiction (3) *Messrs. Sutherland and Weintraub*
476. The American Novel Since 1900 (3) *Messrs. Young and Oldsey*
477. British and American Poetry of the 20th Century (3)
478. British and Irish Drama Since 1890 (3) *Mr. Weintraub*
481. History of English Literary Criticism (3) *Messrs. Sams, Bressler, and Borklund*
488. Modern Continental Drama (3) *Messrs. Weintraub and Wellwarth*
490. Rhetorical Theory and Practice (3) *Mr. Bowman*
491. Literature for Teachers in Secondary Schools (3) *Mr. Bressler*
*498. English Institute (6-12)

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Messrs. Smith and Meserole*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. *Mr. Jewkes*

522. Old English Literature (3) A reading of the more important poetic works in Old English. *Mr. Jewkes*

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Messrs. Peck and Cramer*

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Messrs. Peck and Cramer*

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Cramer*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

*A maximum of 6 credits in one summer.

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the 19th and 20th centuries. *Mr. Davis*

540. Studies in Elizabethan Prose and Poetry (3-6) *Messrs. Reed and Smith*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Mr. Frank*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer. *Mr. Frank*

543. Studies in Early 17th Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700. *Mr. Brady*

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Mr. Frank*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Messrs. Reed and G. Smith*

552. Swift and Pope (3) *Messrs. Sams and Brady*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Brady*

554. Studies in Early American Literature (3) *Messrs. Meserole and Hansen*

555. The Puritans (3) Critical studies of the principal works of English and American Puritans. *Messrs. Meserole and Hansen*

556. Eighteenth Century British Fiction (3) *Mr. Peck*

557. Early 18th Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. American Romanticism (3) The Romantic movement in American literature of the mid-19th century. *Messrs. Rubin, Davis, and Bressler*

561. Studies in the Romantic Movement (3-6) *Messrs. Peck and Cramer*

562. Studies in the Literature of Victorian England (3-6) *Mr. Cramer and Miss Austin*

564. Studies in 19th Century American Literature (3) The major figures treated will vary from year to year. *Messrs. Rubin, Davis, and Oldsey*

573. Studies in 20th Century British Literature (3-6) Major writers and literary movements. *Messrs. Morse and Weintraub*

574. Studies in 20th Century American Literature (3-6) Major writers and literary movements. *Messrs. Young and Lewis*

575. James Joyce (3-6) Alternate terms: *Ulysses* and *Finnegans Wake*. Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed. *Mr. Morse*

576. Hemingway and Faulkner (3) The major works. *Mr. Young*

578. Shaw (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. Eliot (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Mr. Lewis*

581. Contemporary Literary Criticism (3) *Messrs. Sams and Brady*

582. Hawthorne and Melville (3) Detailed study of the major works of both authors and of the relationship between the two men. *Mr. Young*

583. Emerson and Thoreau (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Bressler*

584. Whitman and Dickinson (3) The major texts, with special emphasis on background and language. *Messrs. Rubin and Davis*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature. *Mr. Lewis*

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserole*

590. Research Problems in British Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

591. Research Problems in American Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early 16th century to the present. *Mr. Bayard*

595. Studies in British Fiction (3-6) *Messrs. Sutherland and Weintraub*

596. Studies in American Fiction (3-6) *Messrs. Lewis and Young*

597. Studies in American Poetry (3-6) *Messrs. Rubin, Davis, and Hansen*

598. Readings in English (1-6) Programs of readings in English and American literature, designed to meet specific needs of individual students.

ENTOMOLOGY

Beckford F. Coon, *Head of the Department*
317 Frear Laboratory

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Asquith, Coon, Frear, and Rutschky; Associate Professors Boyle, Smyth, and Snetsinger; Assistant Professor Kearby.

A student majoring in entomology may specialize in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Rutschky*
402. Insect Ecology (3) *Mr. Kearby*
403. (Zool. 403) Systematics (3) *Mr. Boyle*
405. Insect Morphology (3) *Mr. Rutschky*
411. Insect Physiology (3) *Mr. Smyth*
413. Entomology Seminar (1 per term)
429. Insect Control (3) *Mr. Snetsinger*
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

506. Immature Insects (3) The morphology and taxonomy of the immature stages of insects. Spring term, even years.

520. Special Topics (1-6)

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years. *Mr. Smyth*

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications. *Mr. Smyth*

533. Physiology of Nerves, Muscles, and Sense Organs (2-6) Current literature on the function of excitable tissues of insects and other animals. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology. *Mr. Smyth*

540. Insect Resistance in Plants (2) Mechanism, expression, permanence, and measurement of resistance to insects with special reference to farm crops. Spring term, odd years. *Mr. Coon*

EXTENSION EDUCATION

Macklin E. John
Chairman of the Committee on Extension Education
1 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competencies which enable them to become more effective professional workers. Options have been developed for the Colleges of Agriculture and Home Economics. Additional options will be offered as they are developed by other Colleges.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

FAMILY ECONOMICS AND HOME MANAGEMENT

MARJORIE M. KNOLL
Head of the Department of Home Management, Housing, and Home Art
271 Home Economics South

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Harms, Hotchkiss, and Knoll; Associate Professor mith.

Those interested in emphasizing a study of home management, family economics, amily housing, and home equipment may do so through this major. There are no pecific course requirements for admission.

In the graduate program family management practices, their effects upon members f the family unit, and the interaction of such practices with the local and national conomy are studied in relation to principles of economics, philosophy, psychology, ociology, and political science.

ONSUMER SERVICE AND EQUIPMENT (CS EQ)

03. LECTURE-DEMONSTRATION TECHNIQUES (3)
13. HOME EQUIPMENT (3)
50. PROBLEMS IN HOUSEHOLD EQUIPMENT (1-6)

AMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

15. HOUSEHOLD BUYING PRACTICES (3)
19. MANAGING FAMILY FINANCIAL RESOURCES (3)
24. ECONOMIC CONDITIONS IN RELATION TO THE FAMILY (3)
39. MANAGEMENT PRINCIPLES IN HOME OPERATION (2)
42. RESIDENT EXPERIENCE IN HOME MANAGEMENT (3) Room and board will be charged at regular rates. *Miss Chennault*
45. HOME MANAGEMENT EXPERIENCE (3) *Miss Chennault*
77. FAMILY MANAGEMENT (3)

15. CONSUMER PROBLEMS (2-3) Methods of securing, evaluating, and presenting data concerning household commodities. For home economics teachers in high schools, colleges, and adult classes.

24. ECONOMIC PROBLEMS OF THE HOUSEHOLD (3) Economic problems of the present-day family; special emphasis on factors in household production, use of money income, and standards of living.

28. HOME MANAGEMENT SUPERVISION (2-3) Evaluation of objectives and techniques in organization, supervision, and teaching of the home management house experience.

43. HOME MANAGEMENT IN RELATION TO FAMILY LIVING (3) Includes work with families in solution of their management problems.

44. PROBLEMS IN FAMILY ECONOMICS AND HOME MANAGEMENT (1-6) Investigation of selected problems in family economics and home management.

50. SEMINAR IN FAMILY ECONOMICS AND HOME MANAGEMENT (1-6) Discussion and reports on developments in family economics and home management.

FOOD SERVICE AND HOUSING ADMINISTRATION

S. Earl Thompson
Head of the Department of Hotel and Institution Administration
4A Home Economics Building

Degrees Conferred: M.S., M.Ed.

Graduate work in this field trains for management positions in institutions whic provide food service and housing to large groups, such as hospitals, residence halls children's homes, and other public and private organizations. For admission, a studen should have a baccalaureate degree in this or a related field.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (2)
410. Advanced Quantity Food Production (3)
425. Food and Labor Management and Control (3)
461. Personnel Functions in Food Service and Housing Administration (3
470. Problems in Food Service and Housing Administration (3)

502. Problems in Institution Administration (3-6) Individual study of prob lems in institution administration. Prerequisites: F.S.H.A. 310, 330.

FOODS AND NUTRITION

George P. Barron, *Head of the Department*
202B Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., and M.Ed. in Foods and Nutrition; M.S. i Nutrition in Public Health.
Graduate Faculty: Professors Barron, Gordon, and Pike; Associate Professor Olson

Graduate programs in foods and nutrition prepare students for careers in colleg teaching, research, and adult program leadership. The program in nutrition in publi health prepares the student for work in public health agencies.

For admission to a graduate program in foods and nutrition, a student must hav completed at least 9 credits in organic and inorganic chemistry, 3 in biochemistry 3 in microbiology, 3 in physiology, 4 in other physical and biological sciences, an 8 in foods and nutrition.

For admission to the program in nutrition in public health, the requirements are a least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in micro biology, 12 in social sciences, 7 in foods, and 4 in nutrition.

FOODS AND NUTRITION (F N)

400. Special Problems in Foods and Nutrition (1-3)
420. Experimental Cookery (3) *Miss Olso*
421. Cultural and Aesthetic Aspects of Food (3) *Mrs. Jenning*
422. Scientific Principles of Food Preparation (3) *Miss Gordo*
452. Nutritional Aspects of Disease (3) *Miss Pik*
456. Nutrition in the Community (3)

57. Principles of Nutrition (3)
58. Applied Nutrition (2)
59. Advanced Nutrition (3)
90. Foods and Nutrition Seminar (1)

120. Readings in Foods (2) Critical review and reports of literature on selected food topics. *Miss Gordon*

121. Seminar in Foods (1-6) Discussion and reports on current research in the foods field. *Miss Gordon*

122. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation. *Miss Gordon*

130. Problems in Foods and Nutrition (1-6)

150. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

151. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

152. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy. *Miss Pike*

155. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

156. The Survey Method in Foods and Nutrition (2) Study of survey technique as a tool in the assay of food adequacy and nutritional status.

157. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition. *Miss Pike*

FORESTRY

Peter W. Fletcher
Director of the School of Forest Resources
101 Forestry Building

Degrees Conferred: M.S., M.F.
Graduate Faculty: Professors Bartoo, Fletcher, McDermott, Norton, and Ward; Associate Professors George, Gerhold, Hutnik, and Shipman; Assistant Professors Borden, Lindzey, Murphey, and Sopper.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science. The M.F. and M.S. degrees may be granted in the technological programs and the M.S. degree in the scientific programs.

Attention is called to the Ph.D. programs available in such related fields as agricultural economics, agronomy, botany, entomology, genetics, and plant pathology.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in timber management, wildlife habitat management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar

program emphasizing biological science, economics, and applied mathematics provide the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engineering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

FORESTRY (FOR)

416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
445. Improvements (3)
450. Advanced Mensuration (3)
455. Forest Photo Interpretation (3)
466. Forest Resource Management (3)
469. (W.U. 469) Problems in Forestry and Forest Products (1-6 per term)
480. Policy and Administration (3)

504. (W.U. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 78.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Bot. 516.

510. Forestry Seminar (1 per term) Current problems of forest research presented as weekly seminar reports. May be repeated with additional credit for each term's work.

512. Forest Genetics (3) Theoretical and practical application of genetics in forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerequisite: Bot. 22.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forested watersheds. Prerequisites: For. 78, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various

compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

50. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

60. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

75. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 70.

VOOD UTILIZATION (W U)

04. Physical and Mechanical Properties of Wood (3)
05. Adhesives and Glued Wood Products (3)
24. Commercial Tropical Woods (3)
35. Seasoning and Preservation (3)
37. Wood Micro-Technique (3)
62. Defects in Wood (3)
69. (For. 469) Problems in Forestry and Forest Products (1-6 per term)
91. Logging and Lumbering (3)
92. Lumber Properties and Usage (3)
95. Lumber Manufacturing Processes and Cost Analysis (3)
97. Small Sawmills (3)

02. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose. Pulping quality, fiber measurements.

04. (For. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

10. Wood Utilization Seminar (1 per term)

31. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

32. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

40. Chemical Utilization of Wood (3) Wood as a chemical raw material; its chemical properties and conversion processes.

FRENCH

Gérard J. Brault, *Head of the Department*
210 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Belasco, Brault, Chapman, Eyer, Hyslop, and LeSage.

The minimum requirement for admission to an advanced degree program will ormally be 27 credits of post-intermediate work in language and literature. A

student may follow a graduate program in French literature and in descriptive an historical linguistics with a minor in a related field. M.A. candidates may eithe submit a thesis or schedule 6 additional credits in 500-level courses in the major fiel

FRENCH (FR)

417. French Phonology (3)
418. French Morphology and Syntax (3)
422. Old French Literature (3)
426. French Literature of the Renaissance (3)
435-436. 17th Century French Literature (3 each)
445. The Age of Enlightenment (3)
451-452. 19th Century French Literature (3 each)
460. French Prose of the 20th Century (3)
461. French Poetry and Drama of the 20th Century (3)
470. Advanced Composition and Conversation (3)
480. The Teaching of French (4)
*489. French Institute (7-14)
491. Problems in French Literature (3-6)
499. Foreign Study in French (3)

†1G. Elementary French for Graduate Students (3) Designed for student preparing to satisfy language requirements for advanced degrees.

500. An Introduction to Old French (3) Analysis of the phonology, morpho ogy, and syntax of the Old French language based on early literary monuments.

502. Advanced Linguistics (3) Synchronic dialectology; tagmemic and transfo mational analysis of contemporary French spoken language and literary texts. Pre requisite: Fr. 418.

515. Medieval French Literature (3) Familiarizes the student with Old an Middle French texts from the earliest monuments to Villon.

525. French Renaissance Literature (3-6) The origins and development c French Renaissance literature with emphasis on Rabelais, Ronsard, DuBellay, an Montaigne.

532. French Drama of the Classical Period (3) Origins and development c French classical comedy and tragedy, emphasizing the works of Corneille, Racin and Molière.

533. Seventeenth Century Prose and Poetry (3) The development of Class cism; its apogee and decline as seen in the works of major prose writers and poet

543. Eighteenth Century French Literature and Thought (3-6) Voltair Rousseau, Diderot, and other major figures.

561. French Romanticism (3) The Romantic movement in French literature wit emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with em phasis upon its major exponents in prose and poetry.

569. Masters of 20th Century French Literature (3-6) Major literary figur of contemporary French literature.

*A maximum of 7 credits in one summer.
†No graduate credit is given for this course.

581. Theory and Techniques of Teaching French (1-3)

596. Symbolism (3) The anti-positivistic tradition in 19th century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

597. Research Techniques and Bibliography in French Language and Literature (1-3)

598. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

FUEL TECHNOLOGY

Peter H. Given, *Head of the Department of Fuel Science*
316 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Given, Palmer, and Walker; Associate Professors Austin, Essenhigh, and Vastola; Assistant Professor Polansky.

In their programs of courses and research, students may emphasize the chemical, physical, or engineering aspects of solid, liquid, or gaseous fuels. Students are accepted with undergraduate majors in chemistry, chemical engineering, mechanical engineering, physics, or fuel technology.

The department has special facilities for research on high temperature gaseous reactions; reactions of free radicals; combustion of pulverized coal and oil sprays; dust explosions; fuel cells; formation, structure, physical properties, and reactions of carbons and graphites; chemistry of coal macerals; reactions in plasmas; structure and reactions of coals; and special organic reactions of fuel-related materials.

Departmental requirements for the doctorate supplement those of the Graduate School with the stipulation that at least 18 credits be earned in deparmental courses, out of a total requirement of 54 course credits. Each student is encouraged to develop a strong minor in the field most closely related to his area of specialization in fuel technology.

FUEL TECHNOLOGY (F T)

400.	Fuel Technology Research and Design (1-3)	
402.	Chemicals from Fuels (2)	*Mr. Given*
405.	Combustion Calculations (3)	*Mr. Austin*
406.	Gaseous Combustion (3)	*Mr. Palmer*
408.	Combustion and Gasification Engineering (4)	*Mr. Essenhigh*
409.	Cokes, Carbons, and Graphites (2)	*Mr. Polansky*
410.	Fuel Technology Laboratory (2)	*Mr. Polansky and Staff*
414.	Fuel Engineering Analysis (2)	*Mr. Austin*
415.	New Sources of Energy (2)	*Mr. Vastola*

503. Coalification and Coal Chemistry (3) Chemical changes during the coalification process; chemical and physical constitution and classification of coals; relations between coal chemistry and constitution. Prerequisite: Chem. 31. *Mr. Given*

506. Kinetics of Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of coals and carbons. Prerequisites: Chem. 451, F.T. 409. *Mr. Walker*

510. Special Topics in Fuel Technology (1-6 per term)

511. Fuel Technology Seminar (1 per term) Selected topics from current fu technology research examined and discussed.

512. High Temperature Kinetics and Flame Propagation (3) Laminar ar turbulent premixed and diffusion flames; gaseous detonations; rate processes high temperature gases. Prerequisite: F.T. 406. *Mr. Palm*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber cond tions; liquid and solid propellants, slurries, fuel sprays, and finely divided solid Prerequisite: F.T. 406. *Mr. Palm*

515. Catalysis of Fuel Reactions (2) Principles of chemisorption and catalysi mechanisms of specific catalytic reactions and practical aspects of catalytic pro esses in the fuels industries. Prerequisite: Chem. 452. *Mr. Walk*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscop in fuel technology studies are listed under Mineral Sciences.*

GENERAL ENGINEERING

Otis E. Lancaster
Chairman of the Committee on General Engineering
101 Hammond Building

Degrees Conferred: M.Eng., M.Ed.

This program is designed primarily to meet the needs of the engineering faculty the various technical institutes. The objective is to give academic preparation f those individuals who will teach engineering subjects at the two-year college level.

For admission an undergraduate degree in engineering, physical science, math matics, or the equivalent is required.

For either degree a minimum of 30 credits is required in addition to a scholar written report. Twenty-four of these credits should be in engineering, physics, ar mathematics. A candidate is expected to earn at least 3 credits each in mathematic physics, and two fields of engineering, or demonstrate competence in them.

For the M.Eng. degree the 6 remaining credits may be taken in any field approve by the committee. At least 12 credits must be earned in graduate courses (500 series in engineering subjects.

For the M.Ed. the 6 remaining credits must be in education consisting of one credit course in the theory of learning and teaching and one 3-credit course in inter ship in college teaching. Fifteen credits must be earned in graduate courses (5 series).

GENERAL FAMILY STUDIES

Rose M. Cologne
In Charge of Graduate Programs in General Family Studies
20A Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Because this program is planned for teachers in secondary schools or small college and others who wish to become proficient in several areas of home economics, th student must have a strong home economics background for admission.

The major for the M.S. or M.Ed. degree consists of a minimum of 6 credits in each f three areas of home economics. Three areas in this field are also the basis for the najor at the doctoral level. However, the minimum credit requirements in each area re established after consultation with a committee which reviews all previous work. The student chooses a minor field of educational foundations or, if sufficient compe- ence in educational foundations is demonstrated, one of the applied fields, such as ome economics education, secondary education, or higher education.

GENERAL FAMILY STUDIES (G F S)

10. Communities and Families (3)

16, 516v. Methods of Research in Home Economics (3) Review of problems and techniques of research in home economics. Required of all graduate students in home economics.

GENETICS

James E. Wright, *Chairman of the Committee on Genetics*
307 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate programs are offered in the fields of theoretical and applied genetics, ncluding plant and animal breeding. Courses in genetics and breeding are given by arious departments. The basic and theoretical courses are listed under identical umbers in the Departments of Botany and Zoology. Courses dealing with genetic rinciples as applied to specific organisms are offered in the Departments of Agron- my, Animal Science, Dairy Science, Forest Management, Horticulture, Microbiology, nd Poultry Science. The graduate committee for majors shall be appropriately epresented by members of theoretical and applied phases who shall have the re- ponsibility and jurisdiction for determining course work and research acceptable in atisfying degree requirements.

For entry as a major in this field no fewer than 15 credits in basic biology and 15 redits in the areas of chemistry, mathematics, and physics are required.

The following courses are available in genetics or breeding, and their descriptions ay be found under the offerings of the several departments: Agro. 411, 509, 510, 82; A.I. 501, 505; An.Sc. 422; Bot. (Zool.) 405, 422, 505, 524, 528, 533; D.Sc. 13; For. 512; Hort. 444, 501, 514, 520, 524; Micrb. 516; Pty.Sc. 402, 505.

GEOCHEMISTRY

John C. Griffiths
Head of the Department of Geochemistry and Mineralogy
220 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Brindley, Burnham, Goldich, Greig, Griffiths, Keith, sborn, Roy, Vand, and Wright; Associate Professors Barnes, Dachille, Herzog, and hornton; Assistant Professors Gibbs, Hsu, Weber, and White; Mrs. Roy.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOCHEMISTRY (GCHEM)

457. Geochemical Prospecting (2)

501. Research (1-10 per term) Research in geochemistry.

509. Geochemistry Seminar (1 per term)

510. Problems in Geochemistry (1-9) Laboratory and library study of special problems.

512. Crystal Chemistry of Nonmetallic and Defect Solids (2-4) Relation of structure to ionic size, charge, polarizability; influence of p-t environment; chemical-structural defects, diffusion, transitions, and reactions in solids. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams.

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Weber*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Herzog*

518. Isotope-Ratio Variations in Nature (2) Theoretical basis and observations of isotope fractionation in nature: paleotemperature scale; temperatures of formation of ore deposits and other rocks. *Mr. Weber*

519. Cosmochemistry and Nucleogenesis (2) Distribution and composition of matter; origin of solar system and earth, of constituent nuclides, of life. *Mr. Herzog*

520. P-T-X Phase Relations in Mineral Systems (2) Phase equilibrium in mineral systems with pressure as a variable. Prerequisite: Gchem. 513.

522. Geochemistry of Aqueous Systems (3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, Po_2-pH relations applied to ground water, sea water, hydrothermal fluids. *Messrs. Barnes and Schmalz*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Mineral Sciences.*

GEOGRAPHY

Allan L. Rodgers, *Head of the Department*
202 Mineral Sciences Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Deasy, Lewis, Miller, Rodgers, and Zelinsky; Associate Professors Gould, Simkins, and Wernstedt.

The student may concentrate on economic geography, cultural geography, physical geography, one of the major world regions, or acceptable combinations of these fields. In addition, all students receive training in cartographic, statistical, and bibliographic techniques.

Because physical geography is a branch of the physical sciences, and cultural and economic geography are branches of the social sciences, a student may enter graduate work under either of two options. Option 1, for the student who wishes to specialize in physical geography, requires the completion of 18 undergraduate credits in geography and 20 credits in mathematics and biological and physical sciences, including at least 6 credits in geology. Option 2, for the student who wishes to specialize in cultural or economic geography, requires 18 undergraduate credits in geography plus 20 credits in the social sciences, including at least 3 in economics.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) — *Mr. Zelinsky*
402. Cultural and Anthropo-Geography (3) — *Mr. Zelinsky*
405. Geography of Population (3) — *Mr. Zelinsky or Mr. Simkins*
407. Geography of Settlement (3) — *Mr. Simkins*
410. Cartography—Map Design and Construction (3) — *Mr. Deasy*
420. Urban Geography (3) — *Mr. Rodgers*
427. Geography of the Soviet Union (3) — *Mr. Rodgers*
430. Agricultural Geography (3) — *Mr. Whitney*
433. Regional Climatology (3) — *Mr. Wernstedt*
434. Regional Physiography (3) — *Mr. Lewis*
442. Geography of Europe (3) — *Mr. Miller*
443. Geography of the Orient (3) — *Mr. Whitney*
444. Geography of Africa (3) — *Mr. Gould*
445. Geography of Southern Asia (3) — *Mr. Wernstedt*
452. Interpretation of Aerial Photographs (3) — *Mr. Deasy*
456. Quantitative Methods of Geographical Analysis (3) — *Mr. Gould*
460. Political Geography (3) — *Mr. Lewis*
468. Transportation Geography (3) — *Mr. Gould*
480. Geography of Manufacturing (3) — *Mr. Miller or Mr. Rodgers*
490. Physical Geography for Teachers (3) — *Mr. Lewis*

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The literature of some phase of physical geography with emphasis on procedures for organizing material for classroom reports and discussions.

505. Economic Geography Seminar (3-12) The literature of some phase of

economic geography with emphasis on procedures for organizing material for classroom reports and discussions.

506. Cultural and Political Geography Seminar (3-12) The literature of some phase of cultural and political geography with emphasis on procedures for organizing material for classroom reports and discussions.

507. Development of Geographic Thought (1-6) Critical analysis of the growth of geographic thought from antiquity to the present; emphasis on structure of modern geography.

510. Physical Geography Research (3-10) Original study in physical geography: a field problem or detailed library investigation with analysis and presentation of data.

511. Economic Geography Research (3-10) Original study in economic geography: a field problem or detailed library investigation with analysis and presentation of data.

512. Cultural and Political Geography Research (3-10) Original study in cultural and political geography: a field problem or detailed library investigation with analysis and presentation of data.

543. Conceptual Frameworks for Geographical Analysis (3) Simulation, topological, queuing, programming, principal component, and game theory models in solving geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

GEOLOGY

Lauren A. Wright
Head of the Department of Geology and Geophysics
110 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Lattman, Ridge, Scholten, Spackman, and Wright; Associate Professors Parizek, Schmalz, and Williams; Assistant Professor Dutcher.

Students may specialize in stratigraphy, paleontology, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, marine geology and chemical oceanography, coal geology, and geology of metallic and nonmetallic deposits.

Prerequisites for admission include 25 credits in an approved combination of chemistry, physics, mathematics, and biological sciences, and at least 18 credits in geology and mineralogy.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOLOGY (GEOL)

400. Geology for Teachers (3)
410. Structural Geology (3) *Mr. Gold*
420. Paleobotany (3) *Mr. Spackman*
421. Introduction to Coal Petrology (3) *Mr. Williams*
422. Introductory Palynology (3) *Mr. Spackman*

430.	Paleontology (3)	*Mr. Guber*
440.	Marine Geology (3)	*Mr. Schmalz*
451.	Economic Geology (3)	*Mr. Ridge*
452.	Introduction to Hydrogeology (3)	*Mr. Parizek*
453.	Principles of Engineering Geology (3)	*Mr. Voight*
461.	Geology of the United States (3)	*Mr. Wright*
462.	Principles of Geomorphology (3-6)	*Mr. Lattman*
470.	Introduction to Field Geology (3)	
472.	Field Geology (5)	*Mr. Scholten*
481.	Geology of Oil and Gas (3)	*Mr. Scholten*
490.	Stratigraphy (4)	*Mr. Williams*

*500. Geology Seminar (1-9) Presentation, at weekly departmental meetings, of topics selected from geological literature.

†501. Stratigraphy (3-12) Principles of stratigraphic classification, lithofacies and biofacies, faunal zonation, correlation, sedimentation, and paleogeography, illustrated by stratigraphy of classical geologic regions: (a) Pre-Cambrian; (b) Paleozoic; (c) Mesozoic; (d) Cenozoic. Prerequisite: Geol. 430. *Mr. Williams*

†503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology.

504. History and Foundations of Geology (2-4) Theoretical aspects of geology; spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought.

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology. *Mr. Lattman*

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

515. Ore Microscopy (2-3) Theory and use of the ore microscope in identifying ore minerals in polished section, establishing paragenetic sequences, determining manner of deposition. *Mr. Barnes*

‡517. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Mr. Williams*

520. Seminar in Paleobotany (2-6) Current and classic literature concerning evolution, paleoecology, and geologic history of vascular plants. *Mr. Spackman*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Spackman*

526. Problems in Palynology (3-9) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history.

*Credits to be arranged, 1 to 6 per term.
†Credits to be arranged, 3 to 6 per term.
‡Credits to be arranged, 2-3 per term.

530. Geological Problems (1-15) Prerequisite: 10 credits in geology and mineralogy.

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Lattman*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462. *Mr. Lattman*

551. Geotectonics (3-6) Tectonic principles and elements: nature and development of geosynclines, island arcs, mountain structures, stable masses, cratons, mobile belts. *Mr. Scholten*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and microscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks.

571. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

590. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Mineral Sciences.*

GEOPHYSICS

Lauren A. Wright
Head of the Department of Geology and Geophysics
110 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bell and Howell; Associate Professor Herzog; Assistant Professor Lavin.

Students may specialize in geophysical prospecting, seismology, gravity, well logging, tectonics, physical properties of rocks, radioactive age determinations, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, geology, and geophysics; and at least 16 credits of intermediate-level work in any one or a combination of these subjects.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOPHYSICS (GPHYS)

406. Physics of the Earth (3) *Mr. Howell*
407. Well Logging (3)
408. Geophysical Surveying (3) *Mr. Lavin*
415. Gravity and Magnetic Surveying (3)
416. Electrical Surveying (3)
417. Seismic Methods (3)
418. Potential Theory Applied to Earth Problems (3)

500. Geophysical Seminar (1 per term) Discussion of geophysical reports and papers; scientific outlook.

501. Research (1-10 per term) Research in geophysics.

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders. *Mr. Howell*

503. Special Studies in Geophysics (1-9) Special studies of the theories of geophysical methods.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting. *Mr. Howell*

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth. *Mr. Howell*

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration. *Messrs. Herzog and H. D. Wright*

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineral Sciences.*

GERMAN

Stanley R. Townsend, *Head of the Department*
229 Sparks Building

Degrees Conferred: Ph.D., M.A., M.Ed.
Graduate Faculty: Professors de Levie, Ebbinghaus, Shelley, Townsend, and Willson; Associate Professors Beare and Striedieck; Assistant Professor Hohendahl.

There is opportunity for major emphasis upon either literature or philology. Minimum qualifications for admission include 18 undergraduate credits in German; provision is made, however, for admission with limited deficiencies.
A thesis is required of all M.A. candidates in this major.

GERMAN (GER)

401. Advanced Stylistics (3)
430. History of the German Language (3)
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3)
469. Goethe's Life and Works (3)
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

524. Old Saxon (3) Introduction to Old Saxon grammar; readings in Old Saxon texts, both prose and poetry. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

*No graduate credit is given for this course.

HIGHER EDUCATION

Robert E. Sweitzer, *in Charge of Graduate Programs in Higher Education*
113 Education and Psychology Center, Building II

Degrees Conferred: D.Ed., M.Ed.
Graduate Faculty: Professors Edgar, Patrick, Sweitzer, and Wellington.

Graduate students with any undergraduate major may enter the program without other prerequisites. The following courses in higher education are listed under the offerings of the Department of Educational Services: Ed.Ser. 545 to 552 inclusive and 555 (see page 105). To complete a program to meet the student's needs, additional courses will be selected from other departments of the University.

This program is designed to prepare candidates for such positions as college instructor in professional education, college administrator, director of special divisions in education, or educational research worker. It is not open to students who are preparing to give instruction in such subject-matter areas as the arts, humanities, natural sciences, or social sciences. However, candidates for advanced degrees in fields other than higher education may elect it as a minor, subject to the restrictions concerning minors.

Candidates who have not had teaching experience or other approved educational experience will be required to complete an approved apprenticeship before the degree will be conferred.

HISTORY

Robert K. Murray, *Head of the Department*
116 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Brown, Dahmus, Forster, Gray, Green, Hassler, Klein, McNall, Murray, Pundt, and Thaden; Associate Professors Ameringer, Hoogenboom, and Meier; Assistant Professors Frantz and Pixton.

Graduate work is offered in the following fields of history: ancient, medieval, early modern European, modern European, colonial American, 19th century American, modern American, British, Russian, Latin American, Far Eastern, Middle Eastern, political (European or American), diplomatic (European or American), economic (European or American), social and cultural (European or American).

The candidate for the doctor's degree must pass examinations in four of the above fields, one of which is his dissertation field. He must also pass an examination either in a fifth field of history and a single cognate field, or in a study area made up of a number of academic disciplines related to his dissertation field. The candidate for the master's degree selects one broad field (such as modern European or American) for examination and thesis purposes. About half his course credits are selected outside the examination field. He also must take work in a cognate field. A thesis is required of all M.A. candidates in this major.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. All applicants should provide Graduate Record Examination scores with their applications. All prospective doctoral applicants must supply GRE scores.

HISTORY (HIST)

401. Ancient Civilization (3) — *Mr. Borza*
403. The Middle Ages from Constantine to the Crusades (3) — *Mr. Dahmus*
404. The Middle Ages from the Crusades to the Renaissance (3) — *Mr. Dahmus*
408. Intellectual History of the Middle Ages (3) — *Mr. Dahmus*
410. Renaissance and Reformation (3) — *Mr. Green*
413. The Age of Absolutism (3) — *Mr. Green*
417. Nineteenth Century Europe (3)
419. Recent European History (3) — *Mr. Forster*
422. History of the American Frontier (3) — *Mr. McNall*
425. History of American Political Parties (3) — *Mr. Hoogenboom*
427. The Diplomatic History of the United States (3) — *Mr. Ameringer*
428. American Military History (3) — *Mr. Hassler*
431. Colonial and Revolutionary America (3) — *Mr. Frantz*
432. The Formative Period of American History (3) — *Mr. Brown*
433. The Middle Period of American History (3) — *Mr. Klein*
434. The United States in Civil War and Reconstruction (3) — *Mr. Hassler*
435. The Emergence of Modern America (3) — *Messrs. Murray and Hoogenboom*
436. Recent American History (3) — *Mr. Murray*
440. History of England, 1485-1760 (3) — *Mr. Linker*
441. English History Since 1760 (3) — *Mr. Linker*
442. History of Russia to 1801 (3) — *Mr. Thaden*
443. History of Russia, 1801-1917 (3) — *Mr. Thaden*
444. Eastern Europe in Modern Times (3) — *Mr. Thaden*
447. Social and Economic History of Europe Since 1750 (3) — *Mr. Goldschmidt*
448. Intellectual and Cultural History of Modern Europe (3)
449. Diplomatic History of Europe Since 1870 (3) — *Mr. Forster*
452. Social and Cultural History of the United States Since 1783 (3) — *Mr. Brown*
454. Economic Development of the United States (3) — *Mr. Eggert*
456. History of American Labor (3) — *Mr. Eggert*
460. Latin America and the United States (3) — *Mr. Gray*
461. Social and Cultural History of Latin America (3) — *Mr. Gray*
471. History of Modern China (3) — *Mr. Johnson*
472. Twentieth Century China (3) — *Mr. Johnson*
481. The Middle East in Modern Times (3) — *Mr. Goldschmidt*
491. History of the Soviet Union (3) — *Mr. Enteen*
498. Selected Topics in History (3-6)

501. Historical Method (3) — *Mr. Klein*

502. Historiography (3)

504. Medieval Civilization (3-9) — *Mr. Dahmus*

505. The Age of the Reformation (3-6) — *Mr. Green*

508. Studies in European History, 1600-1789 (3-6)

509. Europe Since 1789 (3-6) — *Mr. Forster*

512. Studies in Pennsylvania History (3-6) — *Mr. Klein*

520. Colonial and Revolutionary America (3-6) — *Mr. Frantz*

533. The United States, 1783-1860 (3-6) — *Mr. Klein*

534. The United States, 1860-1900 (3-6) *Messrs. Brown and Hassler*

536. The United States in the 20th Century (3-6) *Messrs. Murray and Hoogenboom*

538. Diplomatic History of the United States (3) *Mr. Ameringer*

539. Economic History of the United States (3) *Mr. McNall*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6) *Mr. Thaden*

545. Studies in Russian and Soviet History (3-6) *Messrs. Thaden and Enteen*

550. Problems in History (3-6)

562. Seminar in Latin-American History (3-6) *Mr. Gray*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Gray*

599. Readings in History (1-6)

HOME ART

William J. McHale, *Chairman of the Division*
258 Home Economics South

A candidate for an advanced degree may choose a minor in home art upon approval by his major department. However, no advanced degree is offered in this field.

FAMILY HOUSING AND HOME ART (FH HAR)

401. Home Furnishings for the Family (3)
*433. Advanced Home Crafts (2-12)
440. Advanced Home Furnishing Problems (3)
441. Special Problems in Home Furnishings (3)
470. Housing Problems and Policies (3)

515. Backgrounds of the Home Arts (3) Evaluation of useful objects in respect to their form, function, and time; selections for exhibition.

530. Problems in Family Housing and Home Art (1-6) Individual investigation, analysis, and presentation.

541. Art in the Environment (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

HOME ECONOMICS EDUCATION

Marjorie East, *Head of the Department*
114 Home Economics Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors East, Hatcher, and Henderson; Associate Professor Ray.

*Not more than 2 credits in each field.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

For admission the student must present approximately 50 credits of undergraduate work from the following areas: home economics education, education and/or psychology, aspects of home economics; the physical and biological sciences; and the social sciences.

HOME ECONOMICS EDUCATION (HE ED)

400, 400v. Special Problems in Home Economics Education (1-3)
406, 406v. Audio-Visual Methods for Home Economics (1-4)
410v. Supervision of Student Teachers (1-3)
427, 427v. Teaching Home Economics (3)
443, 443v. Adult Education in Home Economics (3)
463, 463v. Senior Seminar (2)
466, 466v. Student Teaching (9)
477, 477v. Curriculum Development for Home Economics in Secondary Schools (3)
478, 478v. Appraising Student Progress in Home Economics (3)
479, 479v. Readings in Home Economics Education (1-4)
480, 480v. Problems in Teaching Home Economics (3-6)

502, 502v. Home Economics Instruction at the College Level (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers. *Mrs. East*

503, 503v. Home Economics Teacher Education (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics. *Miss Hatcher*

504, 504v. Educational Issues and Home Economics (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience. *Mrs. East*

510, 510v. Educational Leadership in Home Economics (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics. *Mrs. East*

511, 511v. Internship in Home Economics Supervision and Administration (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision. *Miss Hatcher*

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE

DARRELL E. WALKER, *Head of the Department*
101 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Fleming, Hitz, Larson, Mastalerz, Meahl, Odland, Smith, and Walker; Associate Professors Bergman, McArdle, Pfahl, Ritter, and Tukey; Assistant Professors Craig, Creech, and Haramaki.

Students may specialize in propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various physiological studies of horticultural crop species.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, or plant nutrition and pomology should register for Hort. 501.

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, and biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

HORTICULTURE (HORT)

412. STORAGE OF HORTICULTURAL CROPS (3) *Mr. Ritter*
427. ADVANCED FLORICULTURE (3) *Mr. White*
428. ADVANCED FLORICULTURE (3) *Mr. Mastalerz*
444. ADVANCED PLANT BREEDING (3-6) *Mr. Craig*
447. PROBLEMS IN HORTICULTURE (1-9)
450. FRUIT SCIENCE (3) *Mr. Ritter*
451. FLOWER STORE MANAGEMENT (4) *Mr. Pfahl*
453. NURSERY PRINCIPLES AND PRACTICE (3) *Mr. Brewer*
456. PROBLEMS IN NURSERY PRACTICE (3) *Mr. Brewer*

500. ECOLOGY OF FRUIT PLANTS (3) Factors limiting the distribution and intensity of culture of fruit species and varieties and effect of environmental factors on cultural practices. Spring term, even years. *Mr. Tukey*

501. EXPERIMENTAL PROBLEMS IN HORTICULTURAL SCIENCE (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology. *Mr. Walker*

506. NUTRITION OF HORTICULTURAL CROPS (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

512. PRINCIPLES OF FRUIT AND VEGETABLE STORAGE (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. Winter term, odd years. *Mr. Ritter*

514. PROPAGATION AND IMPROVEMENT OF HORTICULTURE PLANTS (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Mr. Meahl*

517. HORTICULTURAL SEMINAR (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3)

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years.
Mr. Tukey

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

INDUSTRIAL ARTS EDUCATION

John Withall, *Head of the Department of Secondary Education*
164 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professor McGarey; Associate Professor Pendered.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission.

INDUSTRIAL ARTS (I ART)

400. Shop Management and Layout (3)
407. Curriculum Materials and Methods in Industrial Arts (4)
470. Problems in Senior High School Industrial Arts (3)

574. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. Problems in Industrial Arts Education (2-3) Subject matter, projects, methods of manual and informational teaching, aids and devices, selection of text and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. Testing in Industrial Arts (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and grading; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. Seminar in Industrial Arts (2-9) Directed intensive study, investigation, or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING

Benjamin W. Niebel, *Head of the Department*
207 Hammond Building

Degrees Conferred: M.S., M.Eng.
Graduate Faculty: Professors Niebel, Lancaster, Schmidt, Williamson, and Thuering; Associate Professor Ham; Assistant Professors Draper and Raphael.

Graduate study and research are conducted in management science, process design, systems engineering, and human engineering.

For admission a student must have been graduated from an accredited school with a major in industrial engineering. Graduates of other accredited engineering majors may be admitted after completing basic work in industrial engineering.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
402. Engineering Economy (3)
403. Engineering Economy and Statistics (3)
404. Management Science (3)
405. Quantitative Methods in Industrial Engineering III (3)
406. Design of Production Systems (3)
422a,b,c,d,e,f. Industrial Engineering Problems (2-12)
423. Quality Control (3)
424. Job Evaluation (3)
425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Advanced Metal Casting (3)
428. Foundry Engineering (3)
430. Industrial Leadership (3)
432. Industrial Engineering Lectures (1-3)

501. Manufacturing Methods (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. Management Methods (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. Industrial Relations (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 43 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Budgetary Control and Standard Costs (3-6) Divisional budgets as control media; establishing standard cost data, standard cost accounting procedures, and the use of cost variances in controlling manufacturing operations. Prerequisite: I.E. 335.

508. Methods of Operations Research (3) Analytical approach to management decision-making including decision theory, game theory, constrained extremum theory; minimum cost transportation and network models. Prerequisites: Math. 100 and 3 credits in statistics.

509. Methods of Operations Research (3) Theory and application in decision-making including sequencing, line balancing, inventory, replacement, waiting line models, and Monte Carlo simulation. Prerequisites: Math. 100 and 3 credits in statistics.

510. Methods of Operations Research (3) Theory and application of mathematical programming including linear and dynamic programming, and an introduction to nonlinear, integer, and stochastic programming. Prerequisite: Math. 100.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 44 and 3 credits in statistics.

513. Data Processing and Programming (3) Theory and techniques in systems analyses applied to the programming of procedures and operations.

JOURNALISM

Robert M. Pockrass, *in Charge of Graduate Programs in Journalism*
214 Carnegie Building

Degree Conferred: M.A.
Graduate Faculty: Professors Brown, Goodwin, and Marbut; Associate Professors Froke, Harrison, Norris, and Pockrass; Assistant Professor Preston.

The program is designed to give students an understanding of the theory and practice of mass communication, a critical insight into the structure and functions of mass communications industries, an introduction to research on communications problems, and an opportunity to acquire some depth in a minor field of study. Fulfilling the requirements for this degree should qualify students to advance in positions of responsibility and leadership in the professions of journalism, advertising, broadcasting, and public relations; or in communications education and research.

The program is designed primarily for students who have had some professional courses or experience in journalism and mass communications. Other students will be required to complete a series of at least three undergraduate courses.

A thesis and a minor of 12 credits are required of all M.A. candidates in this major.

JOURNALISM (JOURN)

401.	Critics and Ethics of the Mass Media (3)	*Mr. Harrison*
405.	Comparative Foreign Journalism (2)	*Mr. Marbut*
406.	Evaluation and Uses of Mass Communications Research (3)	*Mr. Preston*
421.	Editorial Interpretation (3)	
422.	Cultural Aspects of the Mass Media (3)	*Mr. Pockrass*
424.	Public Affairs Reporting (3)	*Mr. Dulaney*
430.	Journalism in the Schools (3-6)	*Mr. Vairo*
442.	Special Topics in Advertising (3)	
443.	Advertising Campaigns (3)	*Mr. Rotzoll*
444.	Advertising in Contemporary Society (3)	*Mr. Norris*

466. Public Relations Problems (3)
468. Law of Mass Communications (3) *Mr. Smith*
481. News Evaluation and Presentation (3)
485. Comparative Theories of Press Systems (3) *Mr. Norris*
492. (Brcst. 492) Public Affairs Broadcasting (3) *Mr. Froke*
499. Independent Study in Mass Communication (2-6) *Mr. Goodwin*

504. Seminar in the History of Mass Communication (3) *Mr. Marbut*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes. *Mr. Marbut*

506. Seminar in Communications Research (3-6) Methodology of research in media, content, audiences; experimental, case, and field studies; data processing and analysis; report writing; individual projects. *Mr. Preston*

508. The Literature of Journalism (3) *Mr. Brown*

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Goodwin*

540. Seminar in Advertising Problems (3) *Mr. Norris*

MATHEMATICS

James B. Bartoo, *Head of the Department*
231 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Anderson, R. Ayoub, Bartoo, Benton, S. Chowla, Curry, N. Fine, A. Frink, O. Frink, Hunter, Kanwal, H. Krall, Mitchell, Mrowka, Patil, Ribeiro, Schoenfeld, Selfridge, and Sheffer; Associate Professors Axt, C. Ayoub, Gratzer, Harkness, D. G. Johnson, Kist, Mack, and McCammon; Assistant Professors Barnes, Bouwsma, Comstock, A. Krall, M. Petrich, Rung, Stevens, and Wegner.

Graduate courses in all the principal branches of mathematics are offered each year. The department is prepared to direct research in a variety of fields, including function theory, abstract algebra, topology, number theory, statistics, numerical analysis, computer science, applied mathematics, and all aspects of mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

To be admitted to the M.A. or Ph.D. program without undergraduate deficiency, an applicant should have completed at least three courses in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) and 6 in modern algebra (Math. 480-481) or their equivalents. These courses are

essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree.

For the M.A. degree the department offers two options:

(1) The *thesis* option requires 12 credits of 500-series courses, 6-9 credits of thesis, sufficient credits in approved 400-series courses to make a total of 30 credits, and a final (oral) examination based on the thesis and general course material.

(2) The *non-thesis* option requires 18 credits of 500-series courses with grades of A or B, sufficient credits in approved 400-series courses to make a total of 30 credits, and a term paper on an approved topic of mathematics. No final examination is given in this option.

All first-year students who are working toward the M.A. or Ph.D. degree are required to enroll in Math. 498 (Mathematics Seminar, 1 credit) for two successive terms. All M.A. and Ph.D. students, before they have accumulated 48 graduate credits earned at this University or elsewhere, *must* take qualifying examinations in three fields of mathematics and a reading examination in French, German, or Russian. Recommendations for advancement to Ph.D. candidacy are based on these examinations. The comprehensive examination is given after approximately 60 credits and only after the student has passed a reading examination in a second of the foregoing languages.

To be admitted to the M.Ed. program without undergraduate deficiency in mathematics, an applicant should have at least 24 credits in mathematics including at least 6 at the intermediate level beyond calculus.

Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 415, 416, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. and D.Ed. degrees.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. Fourier Series and Partial Differential Equations (3)
407. Foundations of Algebra and Geometry (3)
409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
413-414. Mathematics of Science for Teachers (3 each)
415. Survey of Modern Mathematics for Teachers (3)
416. Mathematical Logic for Teachers (3)
417. Tensor Analysis (3)
418. (Stat. 418) Introduction to Probability Theory (3)
419. Analytical Mechanics (3)
420-421. Introduction to Analysis (3 each)
428. (Phil. 428) Logical Theory (3)
431. Ordinary Differential Equations (3)
441. Matrix Algebra (3)
451. Functions of Several Variables (3)
452. Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elements of Set Theory and Topology (3)
480-481. Introduction to Modern Algebra (3 each)
491. Topics in Applied Mathematics (3-9)
498. Mathematics Seminar (1-6)

500. Analytical Mechanics (3) An exposition of rigid dynamics, the potential function, and Lagrange's equations. Prerequisite: Math. 419 or Phys. 461.

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisites: Math. 44, 421.

508-509. Theory of Functions of a Complex Variable (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

510. Theory of Groups (3) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 535.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisites: Math. 480, 441; or Math. 481.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

516. (Stat. 516) Intermediate Probability Theory (3) Random walk and recurrent events, Markov chains, and the simplest time-dependent stochastic processes. Prerequisite: Math. 418.

517-518. (Stat. 517-518) Advanced Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 501, 541.

520-521. Projective Geometry (3 each) General study of the subject from the postulational standpoint. Prerequisite: Math. 43. Alternate years or as required.

523. Metric Differential Geometry (3) The usual classical treatment of the subject. Prerequisite: Math. 43.

529-530-531. Topology (2 each) Topological, product, compact, metric, and connected spaces; continuous functions, separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

534. Theory of Algebraic Numbers (3) Introduction to the number theory of quadratic fields, with study of the theory of ideals in quadratic and higher fields, with application. Prerequisites: Math. 404, 480.

535. Modern Algebra (3) First graduate course in abstract algebra including the basic theory of semigroups, rings, fields, operator groups, and factorization. Prerequisites: Math. 480, 441; or Math. 481.

537. Theory of Fields (3) Selected topics from field theory including extensions and structure of fields; Galois theory; algebraically closed, ordered, and algebraic number fields. Prerequisite: Math. 535.

538. Theory of Rings (3) Selected topics from commutative and noncommutative ring theory including ideals, the Jacobson structure theory, and special classes of rings. Prerequisite: Math. 535.

539. Lattice Theory (3) Selected topics from lattice theory including complete, modular, complemented, and distributive lattices and applications. Prerequisite: Math. 535.

541. (Stat. 541) Mathematical Statistical Analysis (3) Probability spaces, random variables, distribution and characteristic functions, convergence theorems, univariate and multivariate distribution theory. Prerequisite: Math. 421.

542-543. (Stat. 542-543) Advanced Theory of Statistics (3 each) Exact and asymptotic sampling distribution theory, rigorous treatment of sufficiency, completeness, estimation, and testing. Prerequisites: Math. 410, 541.

550-551. (Phil. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. Numerical Analysis (3) Approximate solution of discrete eigenvalue problems. Prerequisites: Math. 420, 481.

553. Numerical Analysis (3) Topics from interpolation and integration with remainder terms, approximation theory, asymptotic expansions, solutions of differential and integral equations. Prerequisites: Math. 421, 453.

554. (Phil. 554) Metamathematics (3) Prooftheoretic and modeltheoretic study of systems: Gödel's theorem, relative and absolute consistency proofs, decidability, properties of relational structures, mathematical applications. Prerequisite: Math. 428.

555. Selected Topics in Mathematics for Chemists (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions.

556. (Phil. 556) Recursion Theory (3) Recursive functions; recursive and recursively enumerable sets; equivalent formulations of computability; Church's thesis; related topics from current literature. Prerequisite: Math. 428.

560-561. Theory of Differential Equations (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solutions. Prerequisites: Math. 100, 508.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. (Stat. 577) Special Topics in Probability and Statistics (3-12)

578. Special Topics in Topology (3-12)

579. Special Topics in Numerical Analysis (2-12)

MECHANICAL ENGINEERING

Richard G. Cunningham, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus)

Graduate Faculty: Professors Ambrosius, Brickman, Calvert, Cunningham, DiIlio, Meyer, Olson, Queer, and Shearer; Associate Professors DeCarolis, Lestz, McLaughlin, and Schmidt; Assistant Professors Heinsohn and Margolis.

Graduate programs and research facilities are available in dynamic system analysis and instrumentation, automatic controls, fluid amplifiers, combustion and ignition processes, heat transfer, thermodynamics, fluid mechanics, turbulence, machine dynamics, advanced design engineering, lubrication, power generation and utilization, and building research studies. In addition to basic facilities in the mechanical engineering laboratory, the department has several specialty research laboratories. They are: Systems and Controls Laboratory, Air Environment Laboratory, Dynamics Simulation Laboratory, and Automotive Safety Research Laboratory.

The entering student must hold a bachelor's degree in engineering or physical science. If his undergraduate work has not included considerable work in mechanical engineering subjects, he may be required to include these subjects in his program.

MECHANICAL ENGINEERING (M E)

401. Mechanical Engineering (3-12)
402. Air Conditioning and Life Support Systems (3)
403. Rocket Propulsion (3)
405. Small Particle Technology (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration (3)
412. Heat Transfer (3)
413. Internal Combustion Engines (3)
417. Theory of Engineering Instruments (3)
418. Principles of Turbomachinery (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Design Analysis (3)
453. Bearing Design and Lubrication (3)
455. Automatic Control Systems (3)
457. Advanced Mechanisms (3)

502. Advanced Gas Turbines (3-6) Analytical study of gas turbine compressors and turbines; combustion; complex cycles; recent developments. Prerequisite: M.E. 409.

503. Thermodynamic Process Analysis (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. Selected Topics in Mechanical Engineering (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Advanced Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions. Prerequisites: M.E. 412, Math. 451.

513. Advanced Heat Transfer—Convection and Radiation (3) Convection heat transfer in laminar and turbulent flow; two-phase heat transfer, transportation, film and ablation cooling, and radiation heat transfer. Prerequisite: M.E. 412.

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; two-dimensional supersonic flow; oblique shock waves.

520. Nonsteady Flow of Compressible Fluids (2-4) Method of characteristics; general flow problems; boundaries and discontinuities; interaction of discontinuities; wave diagram techniques and applications.

521. Electromagnetic and Thermodynamic Flow Systems (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

540. Simulation of Mechanical Engineering Phenomena (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) The hydrodynamic theory of lubrication and methods of applying it to bearing design, together with a survey of methods of testing lubricants.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. Advances in Control Systems Analyses (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods.

557. Mechanism Synthesis (3) Design and analysis of mechanisms for specific motion and energy requirements; intermittent mechanisms. Prerequisite: M.E. 457.

558. Fluid Control Systems (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY

Robert W. Lindsay, *Head of the Department*
5 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Lindsay, Muan, and Read; Associate Professors Bitler, Healy, Hoke, and Simkovich; Assistant Professor Ryba.

There is opportunity for a student to specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

To be prepared for the graduate program, the applicant should present a bachelor's degree in metallurgy or metallurgical engineering, or a satisfactory bachelor's degree in any other field which has included mathematics through ordinary differential equations; a year of basic physics; three courses in chemistry, including laboratory, and covering inorganic chemistry and preferably physical chemistry; and three courses in metallurgy. Students who lack some of this background can be admitted but will be expected to make up their deficiency without receiving graduate credit.

METALLURGY (METAL)

401. Metallurgical Processes and Kinetics (3)
405. Ferrous Metallography (3)
406. Nonferrous Metallography (3)
407. Metallurgical Engineering I (3)
408. Metallurgical Engineering II (3)
409. Metallurgical Investigations I (2)
410. Metallurgical Investigations II (2)
412. Solid State Metallurgy (3)

501. Metallurgical Problems (1-6 per term) Independent study of special problems in metallurgy.

502. Seminar in Metallurgy (1-6) Conferences, reading, reports, and special lectures.

508. Kinetics of Phase Transformations (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. Introductory Theoretical Physical Metallurgy (3) Quantum mechanics and its application to solid state theory; introduction of Schroedinger's equation, its solutions, free electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452; Metal. 301, 302, 304. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. Prerequisites: Metal. 511, 513. *Mr. Read*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 513. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisites: Metal. 511, 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Chem. 452 or Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513. *Mr. Lindsay*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 511, 513. *Mr. Ryba*

525. Metal Finishing (3) Metallic coatings and their metallurgical properties; theories and problems of application, utilization, and evaluation. Prerequisite: Metal. 515. *Mr. Read*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Mineral Sciences.*

METEOROLOGY

Hans Neuberger, *Acting Head of the Department*
322 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Blackadar, Hosler, Neuberger, and Panofsky; Associate Professors Danielsen, Duquet, and Stephens.

Candidates in meteorology may specialize in aerosol and cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, atmospheric optics and electricity, macro- and microclimatology, agricultural meteorology, synoptic meteorology, or meteorological instrumentation.

Requirements for admission include mathematics through differential equations and one year of college physics. Students with a strong background in mathematics, physics, or engineering may be admitted with deficiencies but must make up such deficiencies before they are admitted to candidacy for a degree.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
411. Introduction to Synoptic Meteorology (3)
418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
443. Physical Meteorology (3)
445. Hydrometeorology (3)
450. Applications of Statistics to Meteorology (3)
451. Thermodynamics of the Atmosphere (3)
452. Hydrodynamics of the Atmosphere (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
492. Meteorological Seminar (1-2)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Mineral Sciences.*

MICROBIOLOGY

ROBERT W. STONE, *Head of the Department*
204 Patterson Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Cone, Dunne, Gentry, Lindstrom, Ludwig, Stone, and Zimmerman; Associate Professors Casida and Heist; Assistant Professors Pootjes and Tershak.

Specialized areas of study include microbial physiology, soil microbiology, food and industrial microbiology, microbial genetics, immunology, bacteriophage, and virology. There is opportunity for research in animal disease in cooperation with the Department of Veterinary Science.

Prerequisites for admission are 20 credits in chemistry including quantitative analysis and organic chemistry, 6 in physics, and 8 in microbiology. Mathematics through calculus is recommended. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work.

MICROBIOLOGY (MICRB)

401. GENERAL MICROBIOLOGY (4)
407. PROBLEMS IN MICROBIOLOGY (1-12)
410. IMMUNOLOGY AND SEROLOGY (4)
411. SURVEY OF MICROBIOLOGY (1 per term)
412. THE BACTERIAL PATHOGENS (4)
413. SOIL MICROBIOLOGY (3)
414. FOOD MICROBIOLOGY (4)
416. INDUSTRIAL MICROBIOLOGY (4)
417. EPIDEMIOLOGY (2)

507. SEMINAR (1 per term) Reports on current fields of research.

508. PHYSIOLOGY OF BACTERIA (2-4) Composition, nutrition, and growth of microorganisms; influence of physical and chemical environment on metabolism.

509. FERMENTATION (2) Chemical activities of microorganisms; mechanisms of fermentative and oxidative metabolism.

512. BACTERIOLOGICAL TECHNIQUES (1-6) Practice in special laboratory techniques including manometry, tissue culture, and serology.

515. (V.Sc. 515) VIROLOGY (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

516. BACTERIAL GENETICS (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

MINERAL ECONOMICS

JOHN D. RIDGE, *Head of the Department*
207 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Ridge and Schanz; Associate Professor McDivitt; Assistant Professor Gordon.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in commodity analysis (fuels, metals, or nonmetals), resource economics (mineral policy or area studies), industrial economics (administration, market research, or financial analysis), or operations research and statistics (resource allocation, forecasting, or exploration programming).

The requirements for admission are 24 credits in chemistry, physics, mathematics, or statistics; 12 credits in the earth sciences; 9 credits in economics, mineral economics, commerce, business administration, or industrial management; and 6 credits in engineering subjects.

Students having a deficiency of 9 credits or fewer in this total of 51 may be admitted as regular graduate students but will be required to make up such deficiencies without the credits being applicable toward the advanced degree.

In addition to the normal degree requirements of the Graduate School, students receiving the M.S. degree must have a minimum of 9 credits of economics (including courses used for admission) and must pass an oral defense of their thesis. Doctoral candidates must complete at least 15 credits of economics (including courses used for admission). The comprehensive examination for the doctorate includes written examinations on the major and minor fields in addition to the oral examination required by the Graduate School.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. The Metals and Their Ores (3)
484. Economics of Energy Resources (3)
486. Petroleum and Natural Gas Economics (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (2)

500. Advanced Principles of Mineral Economics (3-6) Mineral history, research methods in mineral economics, applications of economic theory, mineral policy problems, economics of mineral exploitation, selected readings.

501. Advanced Studies in Mineral Commodities (3-6) Case studies of economic or industrial problems, or both, of selected mineral commodities. Prerequisites: 3 credits in Mn.Ec. 500 and at least 3 credits in Mn.Ec. 453, 483, 484, or 486.

502. Technologic Influences (3-9) Relationship of technologic advancements to economic development of the mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

505. Problems in Mineral Economics (3-12) Individual research involving library, laboratory, or field work to develop solutions to selected techno-economic problems of the mineral industries. Prerequisite: Mn.Ec. 500.

590. Mineral Economics Seminar (1 per term) Preparation and presentation of papers on advanced problems. Required each term in residence.

MINERAL PREPARATION

Harold L. Lovell, *Acting Head of the Department*
4 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Spicer and Sun; Associate Professors McLean and Lovell.

MINERAL PREPARATION

Areas in which students may specialize include the fundamentals of gravity, electrical, and chemical methods of beneficiating natural mineral deposits. Graduate work may also be undertaken on the properties of specific minerals as they are related to beneficiation.

Graduates with a bachelor's degree in such scientific fields as chemistry, physics, and mathematics, and in such engineering fields as mining, metallurgy, ceramics, fuel technology, and mechanical, electrical, and civil engineering are eligible for admission. However, graduates in the above fields are required to take 6 credits of undergraduate courses in mineral preparation along with their graduate program.

MINERAL PREPARATION (MN PR)

401. Advanced Mineral Preparation Laboratory (1)
410. Coal Preparation (3)
420. Unit Operations (3)
430. Flowsheets of Mineral Preparation Plants (3)
457. Field Trip (1-2)

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 420. *Mr. Sun*

504. Mineral Preparation Research (1-6 per term) Research work on specific problems in mineral preparation. Prerequisite: Mn.Pr. 410 or 420.

505. Gravity Processes and Miscellaneous Methods of Mineral Preparation (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and dense-media processes of mineral concentration. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

506. Mineral Preparation Plant Design (3-10) Layout, design, and selection of equipment for specific mineral preparation plant projects. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

507. Chemical Processes of Mineral Preparation (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Mn.Pr. 420. *Mr. McLean*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineral preparation studies are listed under Mineral Sciences.*

MINERALOGY AND PETROLOGY

John C. Griffiths
Head of the Department of Geochemistry and Mineralogy
220 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Professors Brindley, Burnham, Goldich, Greig, Griffiths, Keith, Osborn, Roy, Vand, and Wright; Associate Professors Barnes, Dachille, Herzog, and Thornton; Assistant Professors Gibbs, Hsu, Weber, and White; Mrs. Roy.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, mineralogy, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography (i.e., an equivalent to Min. 485, acceptable to the faculty). Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

MINERALOGY (MIN)

400. (Cer.T. 400) Nonmetallic Crystal Chemistry (2) *Mr. Brindley*
413. Scientific Method Applied to the Earth Sciences (3) *Mr. Griffiths*
463. Optical Mineralogy (3) *Mr. Wright*
483. Petrology (3) *Mr. Thornton*
484. Petrology (2) *Mr. Griffiths*

500. Optical Crystallography of Minerals (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Wright*

501. Petrology (3-6) Microscopic study of rocks, emphasizing classification and genetic relationships. *Messrs. Thornton and Griffiths*

502. Mineralogical Problems (3) Original study of some limited mineralogical or petrological problems.

505. Mineralogy Seminar (1-2) Reading, presentation, and discussion of literature dealing with various phases of theoretical mineralogy. Topics are selected to meet the interests of the majority of the students.

*510. Metamorphic Petrology (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484.

511. Sedimentary Petrology (3-4) Composition, texture, structure, mass properties of sediments; dynamic processes in complex natural systems; sedimentary stages: weathering, erosion, transport, deposition, lithification. Prerequisites: Min. 483, 484. Concurrent: Min. 513.

512. Sedimentary Petrology, Continued (2-4) Diastrophism and tectonic background of sedimentation; depositional loci; classification of sediments: quartzites, graywackes, arkoses; chemical sediments; paleogeography, paleoclimatology, oil finding. Prerequisite: Min. 511. Concurrent: Min. 514.

513. Methods of Analysis of Sediments (3) Principles and practices used in analyzing sedimentary rocks for size, shape, and accessory (heavy) minerals. Concurrent: Min. 511. *Mr. Griffiths*

514. Applied Sedimentology (3) Design and control in analysis of sedimentary rocks; application of these techniques to industrial problems. Concurrent: Min. 512. *Mr. Griffiths*

520. Study of Accessory Minerals (2-4) Detailed study of accessory (heavy) minerals; their significance in problems of provenance, petrogenesis, mineral stratigraphy, and paleogeography. Prerequisites: Min. 511, 512, 513, 514. *Mr. Griffiths*

*Credits to be arranged, 2-4 per term.

524. Introduction to Sedimentation (3) Prerequisites: Min. 483, 484.

525. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Mr. Thornton*

526. Statistical Problems in Sedimentary Geology (3) Application of experimental design, sampling procedures, multiple regression and discriminant analysis in solving problems in sedimentary petrography. Prerequisites: Min. 514; Math. 410 or Agro. 545. *Mr. Griffiths*

527. Igneous and Metamorphic Mineralogy (3) Structural and compositional variations of minerals in igneous and metamorphic rocks. *Mr. Gibbs*

529. Radioactivity in Rocks (1-2) Distribution, mineralogy, and petrology of the radioactive elements. *Mr. Wright*

530. (Cer.T. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Hsu*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Mineral Sciences.*

MINING ENGINEERING

Robert Stefanko, *Head of the Department of Mining*
219 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Kochanowsky and Stefanko; Assistant Professors Maize, Manula, and Singh.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting), mechanization and mine plant (unit operations, materials handling, continuous mining, power supply), development and exploitation methods (mine planning and layout, design of systems), mine management, production engineering and operations research (time study, standards, job rating, operations analysis), environmental control (gas and dust technology, ventilation, air conditioning, hygiene, illumination, safety), and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation).

A bachelor's degree in mining engineering or some related engineering field is required for admission to graduate work. Students may be required to make up deficiencies in their area of specialization. Certain basic, related courses outside the department may be approved as part of the major.

MINING (MNG)

402. Mine Power (3)
410. Mining Engineering Analysis (3)
411. Mine Systems Engineering (3)
412. Mine Management (2)
422. Mine Ventilation and Air Conditioning (3)
431. Rock Mechanics (3)
451-452. Advanced Mining Engineering I and II (1 each)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

525. Dust Technology (3) Physical and chemical properties of dusts; airborne dust determinations and analysis; dust control applicable to mills and mines. Prerequisite: Mng. 422.

532. Rock Mechanics (3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence. Prerequisite: Mng. 431.

541. Theory of Rock Penetration (3) Behavior of rock under dynamic loads intended to penetrate; basic energy relations; application of theory to drilling and other penetration. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Graduate Mining Seminar (1 per term) Preparation and presentation of formal papers on problems of an advanced nature in mining engineering. Required once during each year of residence.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mining studies are listed under Mineral Sciences.*

MUSIC

Robert W. Baisley, *Head of the Department*
232 Arts Building I

Degree Conferred: M.A.
Graduate Faculty: Professors Baisley, Henninger, and Taylor; Assistant Professors Brinsmaid and Case.

In his graduate program a student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, music literature, and creative music.

Admission requires completion of a recognized music major.

A thesis is required of all M.A. candidates in this major.

MUSIC (MUSIC)

407. Piano Literature (3)
410. Music of the 20th Century (3)
411. A Chronological Study of String Literature (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)

*†429. Singer's Style and Interpretation (3) Fee $80.
433. The Singing Voice (3)
455. Form and Analysis (3)
456. Counterpoint (3)
457. Composition (3)
459. Modern Instrumental Arranging (3)
466. Advanced Conducting (3)

*‡501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

*‡503. Advanced Stringed Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*‡511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*‡531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on 20th century practices with attention to traditional idioms that serve as foundation.

557. Symphonic Structure (3) Survey of the evolution and application of the forms used in symphony, sonata, concerto, string quartet, and related works. Prerequisite: Music 369.

*‡558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

563. Free Arranging (3) Correct procedure in arranging for vocal and instrumental ensembles; practical exercises in quartets, glee clubs, and choruses; small instrumental groups, band, and orchestra.

567. The Literature of the Orchestra (3) The suite, symphony, tone poem, and overture from the point of view of appreciation, form, and orchestration.

599. Music Seminar (1-3) Seminar in the history, art, and science of music, with readings, discussion, and performance.

MUSIC EDUCATION

Frances M. Andrews, *Head of the Department*
264 Chambers Building

Degrees Conferred: D.Ed., M.Ed.
Graduate Faculty: Professors Andrews and Dunlop; Associate Professor Campbell.

A student majoring in music education is required to offer a minor in music. However, the master's program must include some work, and the doctoral program considerable work, in the area of general education.

*Course may be scheduled only by conference with the head of the department.
†May be repeated for a total of 27 credits.
‡May be repeated for a total of 18 credits.

Doctoral students may specialize in general vocal, instrumental, or theoretical music in elementary, secondary, or college teaching; but the degree requires work in each of these fields.

For admission to a graduate program a student must have completed a recognized music education major.

MUSIC EDUCATION (MU ED)

446. The Elementary Music Specialist (3)
462. Pedagogy of Theory (3)
468. The Teaching of Piano (3)
469. Band and Orchestra Technique (3)
470. Choral Technique (3)
475. Objectives and Problems in Elementary Music Education (3)
480. Choral Program in the Secondary School (3)
*487. Children's Songs and Records (3)

500. Music Education Seminar (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

569. Present-Day Trends in Instrumental Music (3) New methods and materials for band, orchestra, and ensembles.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

594. Pedagogy of Ear Training (3) Materials and methods for training the listener to grasp, understand, and write what is heard from melody to four-part harmony. Prerequisite: 12 credits in ear training and/or harmony.

NUCLEAR ENGINEERING

Nunzio J. Palladino, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.
Graduate Faculty: Professors Foderaro, Kline, and Palladino; Associate Professors Diethorn, Jacobs, Kenney, and Remick; Assistant Professor D'Ardenne.

*Credit not allowed for students majoring in music or music education.

A student may specialize in reactor physics, neutron and radiation transport phenomena, thermal and mechanical design of reactors, supervision and utilization of research reactors, nuclear materials, or reactor instrumentation and control. Admission requires a bachelor's degree in engineering or in the physical sciences. Students who have not had appropriate undergraduate courses in modern physics and differential equations will be required to schedule them.

NUCLEAR ENGINEERING (NUC E)

401. Introduction to Nuclear Engineering (3)
410-411. Nuclear Engineering (3 each)
420. Radiological Safety (2)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 521.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 100.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

550. Special Topics in Nuclear Engineering (1-12) Theoretical studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 44, Phys. 406.

PHYSICAL SCIENCE (PH SC)

501. Seminar in Nuclear Science and Engineering (0)

PETROLEUM AND NATURAL GAS ENGINEERING

C. Drew Stahl
Head of the Department of Petroleum and Natural Gas
26 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Nielsen, Slobod, and Stahl; Associate Professors Bissey and Burcik.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

Students who expect to enter graduate study in this field with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission.

Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

PETROLEUM AND NATURAL GAS (P N G)

410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
431. Drilling Fluids (2)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)
493. Engineering Evaluation of Oil and Gas Properties (3)
495. Formation Evaluation (3)

510. Flow of Homogeneous Fluids Through Porous Media (3) Applications of vectors, separation of variables, conformal mapping, Laplace transform to describe steady and unsteady state flow in porous media.

511. Material Transfer in Porous Media (3) Diffusion and convective mixing in porous media; solution of the partial differential equations involved; difference methods; mathematical model, viscous instabilities.

512. Reservoir Engineering (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

517. Case Studies of Secondary Recovery (1-3) Interpretation and critical analysis of production and injection characteristics of typical water flood operations. Prerequisite: P.N.G. 515 or 485.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

525. Special Topics in Petroleum Engineering (2-6)

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycles; current developments. Prerequisite: P.N.G. 481.

*535. Seminar (1-3)

540. Special Studies in Petroleum Engineering (1-3) Supervised short study performed in the field, library, or laboratory covering any approved topic related to petroleum engineering.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under* **Mineral Sciences**.

PHILOSOPHY

John M. Anderson, *Head of the Department*
420 Boucke Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Anderson, Bugbee, Finch, Freund, Johnstone, and Mourant; Associate Professors Rosen and Tsugawa; Assistant Professors Gotshalk, Price, and Whittier.

A student may concentrate on history of philosophy, logic and scientific methods, or value theory. The department may waive the requirement of a thesis for M.A. candidates in this major.

Undergraduate preparation should include a major in philosophy, but a strong minor may also be acceptable.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
410. Studies in Greek Philosophy (3-6)
411. Studies in Modern Philosophy (3-6)
412. Studies in Contemporary Philosophy (3)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)
417. Nineteenth Century Philosophy (3)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Classics of Scientific Method (3)
422. Philosophical Logic (3)
426. Metaphysics (3)

*Credits to be arranged, 1 per term.

427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (1-9)
435. Religion and Science (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

507. Seminar in Medieval Philosophy (3-6) Study of one or more important men or movements in medieval philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the 19th century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in 20th century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in 19th Century Philosophy (3-6) Study of a philosopher or philosophical movement of the 19th century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (3-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550-551. (Math. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Metamathematics (3) Prooftheoretic and modeltheoretic study of systems: Gödel's theorem, relative and absolute consistency proofs, decidability, properties of relational structures, mathematical applications. Prerequisite: Phil. 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; recursive and recursively enumerable sets; equivalent formulations of computability; Church's thesis; related topics from current literature. Prerequisite: Phil. 428.

PHYSICAL EDUCATION

Benjamin H. Massey
Associate Dean of the College of Health and Physical Education
238A Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Buskirk, Conger, Coombs, Gross, Harnett, Massey, and Thiel; Associate Professors Lucey, Magnusson, Nelson, and van der Smissen; Assistant Professors Kollias and Stull.

Emphasis may be placed on health education, physical education, or recreation education.

In health and physical education, areas of specialization include (1) foundations (history, philosophy, and principles); (2) kinesiology (applied anatomy and biomechanics); (3) physiology of exercise (physical conditioning, physical fitness, and performance stress); (4) measurement and test construction; (5) adapted physical education; (6) recreation and outdoor education (see Recreation Education, page 178); (7) organization and administration (curriculum construction, intramurals, and interscholastics); and (8) methods and materials in health and physical education. Students may earn a master's degree in recreation education and a doctoral degree in physical education with emphasis on recreation education.

Admission to the M.S. program requires a minimum of 18 credits in health and physical education. Especially desirable is course work in mathematics plus a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended area of specialization. Admission to the M.Ed. program requires a minimum of 18 credits in health and physical education plus 18 credits in education and educational psychology combined, including practice teaching. A year or more of field experience is recommended.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable performance on the Aptitude Test of the Graduate Record Examination or other specified tests.

See also "Recreation Education."

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)

501. Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

PHYSICAL EDUCATION (PH ED)

452. Analysis of Physical Education Activities for the Elementary School (3)
455. Scientific Method in Health and Physical Education (3)
460. Methods and Principles of Athletic Coaching (3)
480. Advanced Anatomy and Physiology, Applied (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)

491. Organization and Administration of Health and Physical Education in Schools (3)

500. Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

530. Research Techniques in Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 490.

531. Research in Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

536. Scientific Methods in Athletic Coaching (3) Unusual techniques in athletic coaching which are not commonly recognized and used; advanced skills and strategy in coaching major sports. Prerequisite: Ph.Ed. 460.

550. Seminar in Health and Physical Education and Recreation Education (1-6)

555. Relationships of Physical Education to the Exact Sciences (3)

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education into the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

581. Problems in Body Mechanics (3) Certain aspects of human motion and body segmental alignment; analysis of human gait, and the dynamic adaptation of the spine, thorax, and pelvis to external physical forces. Prerequisites: Hl.Ed. 244, Ph.Ed. 399.

582. Advanced Kinesiology (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments. Prerequisite: Hl.Ed. 244.

595. Philosophy of Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 491 or Rc.Ed. 465.

PHYSICAL SCIENCE

Henry W. Knerr
Chairman of the Committee on Physical Science
101 Willard Building

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, includes at least 24 credits in physical science chosen from chemistry, earth sciences, mathematics, and physics and a minor of at least 6 credits in education. A candidate is required to earn at least 15 credits in chemistry and physics with a minimum of 6 in each, and at least 3 credits each in earth sciences and mathematics. The completion of a satisfactory term paper and a course in integral calculus is also required.

For admission to the M.Ed. program a student is expected to have completed at least one year each in college chemistry and college physics, mathematics through trigonometry, and 18 credits in education and related psychology. For admission to the D.Ed. program a course in integral calculus is also required.

The D.Ed. program requires a minimum of 60 credits in physical science of which 24 may be in courses designed specifically for teachers. At least 12 credits each in chemistry and physics must be selected from standard courses at the 400 and 500 level. A minimum of 15 credits each is required in professional education and thesis research. The thesis may be based on an experimental study in chemistry or physics or on the study of a problem in the teaching of physical science.

See also "Earth Sciences," "Chemistry," "Mathematics," and "Physics."

PHYSICS

David H. Rank, *Head of the Department*
101 Osmond Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Professors Bleuler, Brickwedde, Frankl, Gibbons, Knerr, McCubbin, Müller, Pratt, Rank, Schilling, Webb, and Wiggins; Associate Professors Atwater, Bauer, Cutler, Kazes, Kendall, McKelvey, Strother, and Weber; Assistant Professors McCammon and Thwaites.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, crystal structure, solid state, field emission, acoustics, high-pressure physics, biophysics, plasma physics and shock waves, low-temperature physics, nuclear physics, physics of high polymers, and various phases of theoretical physics.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed 18 credits in college physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including Phys. 400 and 458 and approved laboratory work such as Phys. 470; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
411. Theoretical Mechanics (3)
412. Introduction to Solid State Physics (3)
417. The Teaching of Physics (3)
420. Intermediate Heat (3)

433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
436. Optics for Teachers (3)
437. Heat, Wave Motion, and Sound for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
441. Demonstration Experiments for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)
477. X-ray Analysis of Solids and Liquids (3)

507. Thermodynamics and Kinetic Theory (3) Classical and modern thermodynamics; introduction to statistical mechanics.

509. Physics Seminar (1-3 per term) Topics from current research.

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics, theory of ensembles, degenerate gases, applications to low temperature effects and cooperative phenomena. Prerequisites: Phys. 507, 561.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle; canonical transformation; Lagrange and Poisson brackets; Hamilton-Jacobi equations; classical theory of fields. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and visco-elastic media. Prerequisite: Phys. 530.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

560. Research Problems (1-10) Introduction to research through individual assignments.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

575. Special Topics (1-3 per term) Theoretical studies in any field of modern physics with or without associated experimental work. Prerequisite: Phys. 456.

PHYSIOLOGY

Richard D. Schein
Chairman of the Committee on Physiology
211 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

This is an interdisciplinary program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area..

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal science, biochemistry, biophysics, and zoology, and the Human Performance Research Laboratory. The instructional staff is composed of the program committee as well as faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cellular and subcellular physiology, environmental physiology, endocrinology, applied physiology (human performance), physiology of nutrition and metabolism, or comparative physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements.

The following courses are available for physiology majors, and their descriptions may be found under the offerings of several departments: Anthy. 401; A.Ntr. 401, 402; Bioch. 401, 402, 417, 436, 437, 501, 517, 519, 520, 521; Bphys. 473, 474, 475, 580; D.Sc. 427, 431, 512, 515, 521; F.N. 452, 457, 459, 552, 557; Micrb. 401, 508; Psy. 402, 403, 503; V.Sc. 400; and Zool. 401, 471, 541, 583, 587.

PLANT PATHOLOGY

James Tammen, *Head of the Department*
111 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Boyle, Graham, Hyre, Kneebone, Lewis, Mills, Tammen, and Wernham; Associate Professor Bloom; Assistant Professor Wood.

A student may specialize in the study of plant diseases caused by fungi, bacteria, nematodes, or viruses, and/or in their control, especially by plant breeding or biological or chemical means. Special study may also be undertaken in the area of

ecology of root diseases, epiphytology, the nature of disease resistance, or physiology of disease.

For admission a student must present at least 27 credits in botany, plant pathology, and biological science, of which not more than 6 may be in biological science. As many as 6 credits may be made up as undergraduate deficiencies after the candidate has been admitted to the Graduate School.

See also "Botany" and "Genetics."

PLANT PATHOLOGY (P PATH)

408.	Plant Pathological Techniques (3)	*Mr. Bloom*
410.	Intermediate Plant Pathology (1)	*Mr. Wuest*
411.	Diseases of Ornamental and Floricultural Plants (2)	*Mr. Nelson*
412.	Advanced Forest Pathology (2)	*Mr. Merrill*
413.	Diseases of Field Crops (2)	
414.	Diseases of Fruit and Vegetable Crops (2)	*Messrs. Bloom and Boyle*
429.	Phytonematology (3)	*Mr. Bloom*

501. Clinical Plant Pathology (3) Advanced course in diagnostic techniques to acquaint the students with specialized procedures for field and laboratory identification of plant diseases. Prerequisites: P.Path. 10, 408, Bot. 419. Summer term, odd years.

510. Advanced Plant Pathology (3) Principles of plant disease development; emphasis on physiology of suscept-pathogen interactions and on development of epiphytotics. Prerequisites: P.Path. 410, Bot. 419. Winter term, odd years. *Mr. Tammen*

515. Disease Resistance in Plants (2-4) Stability of resistance, selection of resistant material, economics of control, special problems. Prerequisites: Bot. 22 or 33, P.Path. 10. Fall term, odd years. *Mr. Wernham*

518. Special Problems (1-12) The prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Virus Diseases of Plants (3) Nature, symptomatology, transmission, and control of virus diseases of plants. Fall term, even years. *Mr. Boyle*

520. Plant Pathogenic Bacteria (3) Bacteria causing plant diseases; methods of identification, inoculation, and control. Spring term, odd years *Mr. Kneebone*

530. Plant Disease Control (3) Methods, and laboratory and field testing of materials used in plant disease control. Spring term, even years.

531. Plant Pathology Seminar (1 per term) Selected topics of current research, history, and contemporary trends in plant pathology. *Mr. Tammen*

POLITICAL SCIENCE

William R. Monat, *Acting Head of the Department*
129 Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Professors Aspaturian, Atwater, Brewster, Ferguson, Masters, McGeary, Monat, and Silva; Associate Professors Albinski and Thurber; Assistant Professor Leduc.

Students may specialize in American government, public administration, political theory, international relations, or comparative government.

Applicants for admission will be expected to have at least 12 credits in political science or its equivalent. In exceptional cases students may be permitted to make up deficiencies after beginning their graduate programs.

The department may waive the requirement of a thesis for M.A. candidates in this major.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Messrs. Masters and Pettit*
411. American Political Theory (3)
412. International Organization: Economic and Social Welfare Functions (3) *Mr. Atwater*
413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian and Atwater*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*
415. International Organization: Political and Security Functions (3-6) *Messrs. Aspaturian and Atwater*
416. International Law (3) *Messrs. Aspaturian and Jordan*
417. American Local Government and Administration (3) *Mr. LeDuc*
419. Bureaucracy and Public Policy (3) *Mr. Monat*
421. Modern Political Theory (3)
426. Political Parties (3) *Miss Silva*
427. Political Opinion and Propaganda (3) *Miss Silva and Mr. Pettit*
431. Ancient and Medieval Political Theories (3)
433. The Law of Labor-Management Relations (3) *Mr. Brewster*
442. American Foreign Policy (3) *Mr. Atwater*
444. Government Regulation (3) *Mr. Ferguson*
445. Administrative Law (3) *Mr. Brewster*
447. Constitutional Law: The Federal System (3) *Miss Silva*
448. Constitutional Law: Government and the Individual (3) *Mr. Brewster*
449. Anglo-American Legal Systems (3) *Mr. Albinski*
450. Politics and Institutions of the British Commonwealth (3) *Mr. Albinski*
451. Politics and Institutions of Western Europe (3) *Mr. Albinski*
453. Politics and Institutions of Developing Areas (3-6) *Mr. Thurber*
456. Politics and Institutions of Latin-American Nations (3) *Mr. Jordan*
457. International Politics of Latin America (3-6) *Mr. Jordan*
458. Governments and Foreign Policies of the Far East (3-6) *Mr. Kochanek*
499. Foreign Study in Government (2-6)

500. Political Power (3-6) Subject to be announced.

505. Executive Power (3-6) *Miss Silva, Messrs. Ferguson and Monat*

509. Scope and Method of Political Science (3-6)

512. Comparative Political Systems (3-9)

515. International Politics (3-6)

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

518. Latin-American Politics (3-6) Forces which shape the quest for power and the process by which public policies are determined.

521. Modern Democratic Political Theory (3-6)

522. Comparative Foreign Policies (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Mr. Aspaturian*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

527. Politics and Legislative Behavior (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Mr. Masters*

528. Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies. *Mr. Masters*

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form. *Messrs. Ferguson and Monat*

530. Public Law (3-6) The nature of law and its role in modern society. *Mr. Brewster*

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Mr. Aspaturian*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought.

571. Theory of Public Administration (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Monat*

572. International Development Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. Thurber*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. Thurber*

575. Government Manpower Management (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline.

576. Government Fiscal Decision-Making (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *Mr. Monat*

577. Organization and Systems Management (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Ferguson*

578. Public Planning and Development Administration in the United States (3) Public planning agencies and their functions; essentials of effective planning and zoning; current trends and problems. *Mr. LeDuc*

580. Internship in Public Administration (6)

POULTRY SCIENCE

ARTHUR J. G. MAW, *Head of the Department*
103 Weaver Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Bressler, Buss, Hale, Maw, Mueller, and Murphy; Associate Professor MacNeil.

The department offers two types of graduate programs. Students interested in genetics or physiology may participate in these interdisciplinary programs with thesis research in the Department of Poultry Science. (See "Genetics" and "Physiology" for admission requirements.)

The programs in behavior, food technology, management, and nutrition consist of a major in poultry science and a minor in one or more basic science departments. Admission requirements include 30 credits in biology, chemistry, mathematics, and physics.

POULTRY SCIENCE (PTY SC)

401. (Psy. 401, Zool. 401) ANIMAL BEHAVIOR (3) *Mr. Hale*
402. SPECIAL TOPICS (3-12)
405. POULTRY PRODUCTION TECHNOLOGY (3)

502. ADVANCED POULTRY NUTRITION (2-4) *Mr. Murphy*

503. ADVANCED POULTRY FARM MANAGEMENT (2-4) *Mr. Bressler*

504. ADVANCED MARKET POULTRY AND EGGS (2-4) Prerequisites: Fd.T. 202; Ag.Ec. 33 or 2 additional credits in poultry science. *Messrs. Mueller and MacNeil*

505. RESEARCH IN POULTRY SCIENCE (1-10 per term) Prerequisite: 9 credits in poultry science.

506. SEMINAR IN POULTRY SCIENCE (1-6)

582. (Psy. 582, Zool. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale and Schein*

NOTE: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

PSYCHOLOGY

DALE B. HARRIS, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.S.
Graduate Faculty: Professors Bernreuter, Carpenter, Cofer, Hale, Guest, Guthrie Hall, Harris, Leibowitz, Lepley, Lundy, Mitzel, Rabinowitz, Smith, VanOrmer, and Warren; Associate Professors Gorlow, Hoffman, Palermo, Piers, Prokasy, Schipper Singer, Thevaos, and Whaley; Assistant Professors Freeman and Seibel.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, measurement and statistics, social and personality, developmental, clinical, school, industrial and business, engineering and human factors.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computer Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a junior-senior scholastic average of B, a minimum of 12 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test. Applicants with a master's degree will have their admission evaluated with emphasis on the quality of their graduate program.

PSYCHOLOGY (PSY)

401.	(Pty.Sc. 401, Zool. 401) Animal Behavior (3)	*Mr. Hale*
402.	Sensation and Perception (3)	*Mr. Freeman*
403.	Introductory Physiological Psychology (3)	*Mr. Warren*
404.	Learning and Motivation (3)	*Mr. Hall*
405.	The Experimental Psychology of Visual Perception (3)	*Mr. Leibowitz*
406.	Experimental Social Psychology (3)	*Mr. Singer*
408.	Comparative Psychology (2-4)	*Mr. Warren*
410.	History of Psychology (3)	*Mr. Leibowitz*
412.	Abnormal Psychology (3)	
415.	Intermediate Statistics in Psychology and Education (3)	*Mr. Prokasy*
417.	Social Psychology (2-3)	*Mr. Guthrie*
418.	Measurement of Personality (3)	
419.	Guidance and Education in Sexual and Marital Adjustment (3)	
422.	Psychological Methods of Measuring the Reactions of the Public (3)	*Mr. Guest*
425.	Psychology of the Elementary School Child (2-3)	*Mr. Whaley*
426.	Adolescence (2-3)	*Mr. Harris*
427.	Psychological Principles in Advertising (3)	*Mr. Guest*
428.	Opinion Research Laboratory (3)	*Mr. Guest*
430.	Verbal Behavior and Verbal Learning (3)	*Mr. Cofer*
431.	Industrial Psychology (3)	*Mr. Smith*
432.	Introductory Engineering Psychology (3)	*Mr. Schipper*
433.	Psychology of Occupational Behavior (2)	
436.	Mental Hygiene in Schools (3)	*Miss Dortort*
437.	Psychology of Adjustment (3)	*Mr. Gorlow*
438.	Theory of Personality (3)	*Mr. Gorlow*
440.	Psychology Projects (1-6)	
441.	Industrial Motivation and Morale (3)	
445.	(C.D.F.R. 445) Development Throughout Adulthood (3)	*Mr. Britton*
474.	Psychology of Exceptional Children (3)	*Miss Piers*
482.	Introduction to Clinical Psychology (3)	*Mr. Galbraith*

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

501. Advanced Psychology (3) Comprehensive study of general psychology. Prerequisite: 9 credits in psychology. *Mr. Lepley*

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of

sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology. *Mr. Warren*

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 or Ed.Psy. 421.

511. Seminar in Contemporary American Psychology (2-3) Current systems or schools of psychology with comparative study and critical analysis; points of view as presented by recognized leaders. Prerequisite: 9 credits in psychology.

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

522. Survey Research Techniques (3) Sample and questionnaire designs for investigation of consumer reactions and social issues, and appropriate analytic procedures. Prerequisite: 3 credits in statistics. *Mr. Guest*

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

528. Opinion Research Administration (3-6) Practicum in planning, development of techniques, and administration of the sample survey. Prerequisites: Psy. 15, 21, 422. *Mr. Guest*

529. (C.D.F.R. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisite: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

534. Seminar in Engineering Psychology (3-6) Experimental studies of psychological factors affecting design and operation of machines. Prerequisites: Psy. 402, 404; Psy. 432 or 501.

535. Human Development (2-3) Psychological phases of human development throughout the life span; implications for school, community, and home. Prerequisite: 9 credits in psychology.

536. (C.D.F.R. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

537. Seminar in Industrial Psychology (3) Prerequisite: Psy. 431. *Mr. Smith*

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421. *Mr. Smith*

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental and clinical investigation of basic drives. *Mr. Hal*

540. Seminar in Clinical Problems (1-6) Contemporary psychological theory

research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality and relevant research with emphasis upon normal processes. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (3)

549. (C.D.F.R. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

555. Theory and Practicum in Clinical Assessment (3) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

556. Theory and Practicum in Clinical Assessment of Pathological Syndromes (3) Current research and theoretical issues in the clinical assessment of pathological syndromes; includes practicum. Prerequisite: Psy. 555.

558. Clinical Child Psychology (3) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 425, 426, 555, 561.

559. The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment; includes principles of school psychology. Prerequisites: Psy. 425, 426, 555. *Miss Piers*

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-6) Practical experience in the Psychology Clinic in advanced nondirective therapy techniques; staff meetings; case conferences.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Pty.Sc. 582, Zool. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale, Schein, and Warren*

590. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION

Robert J. Mowitz
Director of the Institute of Public Administration
302 Engineering E

Degree Conferred: M.P.A.
Graduate Faculty: Professors Brewster, Ferguson, Monat, and Silva; Associate Professor Thurber; Assistant Professor LeDuc.

All candidates take a core program and may concentrate through electives in one of the following areas: general public administration, municipal management and public planning, or international development administration.

Candidates must present for admission, or make up without graduate credit, at least 6 credits in political science and at least 3 credits in each of the following fields: economics, public finance, accounting or statistics, and psychology.

RECREATION EDUCATION

Benjamin H. Massey
Associate Dean of the College of Health and Physical Education
238A Recreation Building

Degrees Conferred: M.S., M.Ed.
Graduate Faculty: Professors Coombs, Gross, and Massey; Associate Professors Nelson and van der Smissen; Assistant Professor Stull.

Programs in recreation education emphasize preparation for positions in administration, supervision, teaching, and research with municipal, state, and federal park and recreation agencies; colleges and universities; semipublic and private agencies; hospitals and institutions; and for leadership of groups in special settings, such as camping or outdoor recreation areas.

For admission a bachelor's degree is required in recreation education or park administration, or in a related field; e.g., forestry, horticulture, landscape architecture, sociology, history, fine arts, or physical education. Students who lack prerequisite undergraduate recreation courses may be admitted but are required to make up the deficiency without degree credit. A student desiring to earn a doctoral degree may major in physical education with emphasis on recreation education.

Courses offered by other departments germane to an articulated recreation program include For. 416, 466, 480; L.Arch. 471, 518; Pl.Sc. 571, 575, 576; and Soc. 470.

RECREATION EDUCATION (RC ED)

430. Camping and Outdoor Education (3)
434. (L.Arch. 434) Recreation Areas and Facilities (3)
456. Social Recreation (3)
461. Community Recreation (3)
465. Administration of Recreation (3)

530. Camp Administration (3) Camp site development; staff selection, training, and supervision; development of objectives and program planning; values inherent in outdoor and camping education. Prerequisite: Rc.Ed. 430.

560. Administrative Problems of Recreation (3) Administrative problems in park and recreation departments; departmental organization, finance, personnel, facilities, program, and public relations. Prerequisite: Rc.Ed. 465.

RURAL SOCIOLOGY

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Professors Bonser, Brown, and John; Associate Professors Bealer, Bylund, Copp, and Fliegel.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at this University during the early part of his master's program.

RURAL SOCIOLOGY (R SOC)

401. Special Topics in Rural Sociology (1-6)
402. Consumer Behavior and the Agricultural Industry (3) *Mr. Bylund*
444. Rural Life in an Industrial Society (3)
452. Rural Organization (3) *Mr. Copp*
459. Rural Social Psychology (3)

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology. *Mr. Bealer*

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems. *Mr. Bealer*

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452. *Mr. Copp*

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior. *Mr. Bylund*

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system with emphasis on techniques of organization and program development. *Mr. Brown*

516. Change in Rural Society (2) Social change in rural society emphasizing prediction and control of the change process. *Mr. Fliegel*

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING

BENJAMIN A. WHISLER
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.
Graduate Faculty: Professors Kountz and Whisler; Associate Professor Nesbitt.

The entering student should be a graduate in sanitary engineering from an accredited college of engineering, but a graduate in civil engineering may obtain the M.S. in sanitary engineering by taking a limited amount of extra undergraduate work in subjects appropriate to the sanitary engineering field. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 471, 472, 571, 572, 573, 574, 575, 576, 577, and 578. Appropriate courses offered by other departments include: Ag. 400; Bioch. 425, 436; Chem. 405; Cmp.Sc. 402; Geol. 452; Meteo. 445; Micrb. 401, 414; Nuc.E. 420; Pl.Sc. 419; and Zool. 410.

SCHOOL PSYCHOLOGY

JOSEPH L. FRENCH
Chairman of the Committee on School Psychology
119 Education and Psychology Center, Building II

Degrees Conferred: D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Carriker, French, Harris, Lundy, and Rabinowitz; Associate Professors Frick, Hottel, Lathrop, and Thevaos.

This interdisciplinary program based on courses in psychology, educational psychology, special education, and related fields is designed to produce dually oriented professionals who are well prepared in both psychology and education. The objective is to develop a psychologist who is interested in and knowledgeable about schools. The school psychologist must utilize his professional skills and his knowledge about children and youth to make contributions which are meaningful to and utilized by teachers. The development of competencies needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Other areas of study related to school psychology, such as clinical psychology, general educational psychology, counselor education, and child development, are found in other departments of the University.

Practicum facilities include the speech pathology and audiology out-patient service, the Reading Center, the Psychology Clinic, and the Demonstration School for mentally retarded children. Facilities for work with children are available through other departments also.

An undergraduate major in psychology or in education of exceptional children is expected of applicants, but students with less than 15 credits in psychology may be admitted with limited deficiencies to be made up concurrently with their graduate studies. Requirements for admission include a minimum junior-senior scholastic average of B and a satisfactory scholastic aptitude rating. Applicants with a master's degree will be required to show more than a minimum success in graduate study, including at least one-third of their graduate credits of "A" quality.

SECONDARY EDUCATION

JOHN WITHALL, *Head of the Department*
164 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Fagan, Fowler, McGarey, Patrick, Remaley, and Withall; Associate Professor Kozak.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the requirements, including residence, described in the earlier sections of this bulletin. For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the head of the Department of Secondary Education. When course work has been completed more than five years prior to admission to the D.Ed. or when it is transferred from another institution, the head of the department will determine its suitability for any part or all of the 15 hours required.

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the head of the Department of Secondary Education. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or chemistry. These programs require 6 credits in professional education approved in advance by the head of the department responsible for the minor field chosen; e.g., secondary education, agricultural education, etc.

SECONDARY EDUCATION (SEC ED)

400. INTRODUCTION TO RESEARCH LITERATURE (3)
426. TEACHING MATHEMATICS IN THE SECONDARY SCHOOLS (4)
433. TEACHING SOCIAL STUDIES IN THE SECONDARY SCHOOLS (4)
436. TEACHING OF CONSERVATION OF NATURAL RESOURCES IN THE SECONDARY SCHOOL (3)
437. TEACHING OF CONSERVATION OF NATURAL RESOURCES IN THE SECONDARY SCHOOL (3)
438. TEACHING SCIENCE IN THE SECONDARY SCHOOLS (4)
443. READING PROBLEMS IN THE SECONDARY SCHOOL (2-3)
445. (El.Ed. 445) TECHNIQUES IN REMEDIAL READING (2-6)
451. SECONDARY EDUCATION IN AMERICA (3)
453. TEACHING ENGLISH IN THE SECONDARY SCHOOLS (4)
454. EXTRACURRICULAR ACTIVITIES IN THE JUNIOR AND SENIOR HIGH SCHOOL (2-3)

472. Measurement of Achievement in the Secondary School (2-3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 406, and teaching experience.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Bot. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec.Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. (El.Ed. 546) Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (3) Historical, psychological, social, and economic factors influencing secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

556. Reading Clinic Practice: Analysis of Reading Disabilities (3-6) Analysis of extreme reading disabilities and recommended procedures; experience in preparation of case reports. Prerequisite: Sec.Ed. 445 or El.Ed. 444.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

SLAVIC LANGUAGES AND LITERATURES

William R. Schmalstieg
Acting Head of the Department of Slavic Languages
127 Sackett Building

Degree Conferred: M.A.
Graduate Faculty: Professor Magner; Associate Professor Schmalstieg; Assistant Professor Birkenmayer.

Programs leading to the master's degree in this field offer opportunities for specialization in literature or linguistics. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.

The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)
450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)

*1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. Russian Texts (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

501. Readings in Russian Literature (3-6) Prerequisite: Rus. 204.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. Russian Literature to Pushkin (3) Russian literary monuments in the original, 1100-1800.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

SLAVIC (SLAV)

500. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literature.

*No graduate credit is given for this course.

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

SOCIAL STUDIES

Hugo A. Meier
Chairman of the Committee on Social Studies
112 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

SOCIOLOGY

Donald P. Kent
Head of the Department of Sociology and Anthropology
240 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Professors Clark, Foreman, Kent, Mather, and M. B. Matson; Associate Professors Dansereau and Theodorson; Assistant Professors DeJong and Westby.

Undergraduate preparation must include 12 credits in sociology and at least 6 in other social sciences. Students of exceptional ability who are deficient in undergraduate preparation may be accepted provided they make up their course deficiency without graduate credit.

A thesis is required of all M.A. candidates in this major.

SOCIOLOGY (SOC)

400. Advanced General Sociology (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)

408. Social Ecology (3)
413. Methods and Techniques of Social Research (1-6)
418. The Development of Social Thought (3)
422. History of Sociological Theory (3)
423. Population Research (3)
424. Social Change (3)
426. Public Welfare Policy and Services (3)
427. Social Case Work (3)
428. Seminar in Sociology (1-6)
429. Social Stratification (3)
444. Complex Organizations (3)
446. Political Sociology (3)
450. Community Organization (3)
454. Industry and the Community (3)
455. Occupations and Professions (3)
456. Readings in Sociology (1-9)
457. Field Work in Industrial Sociology (1-6)
470. Intermediate Social Statistics (4)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the overall structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

505. Current Social Theory (3) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

510. Field Work in Sociology (1-6)

513. Seminar in Sociological Research Problems: A. Research Techniques; B. Current Research (3-6) Prerequisite: 3 credits in statistics.

515. Seminar in Community Studies (3)

523. Population Problems (1-6)

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572. Methods of Sampling (3) Application of sampling techniques to sociological research.

SOLID STATE TECHNOLOGY

Rustum Roy
Chairman of the Committee on Solid State Technology
121 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

The aim of this program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The subject matter, taught by various departments, is grouped into four areas: (1) the structure of solids, (2) theory related to the solid state, (3) properties of solids, and (4) reactions of solids.

Course work should be so distributed that one area is encompassed in depth while a substantial number of credits is chosen from any combination of the other areas. Thesis research on various aspects of the solid state may be conducted in appropriate departments in the Colleges of Engineering, Mineral Industries, and Science, and in the Materials Research Laboratory.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. They should be specifically interested in an interdisciplinary program of study and research.

SPANISH

Anthony M. Pasquariello
Head of the Department of Spanish, Italian, and Portuguese
212 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Bleznick, Moser, Pasquariello, and Sturcken; Associate Professor Brentin; Assistant Professors Dalbor and Triolo.

The minimum requirement for admission to an advanced degree program will normally be 24 credits of post-intermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

SPANISH (SPAN)

400. Advanced Composition and Conversation (3)
404. The Evolution of Spanish (3)
413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)

*450. Spanish Institute (7-14)
452. Spanish Literature in the Romantic Period (3)
459. The Generation of 1898 (3)
472. The Contemporary Spanish-American Novel (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
482. Spanish Lyric Poetry (3)
483. Spanish Drama of the 19th Century (3)
487. The Spanish Novel of the 19th Century (3)
498. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation.

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials.

505. Old Spanish: Phonology, Morphology, and Syntax (3)

506. History of the Spanish Language (3)

510. Spanish Descriptive Linguistics: Phonology (3)

511. Spanish Descriptive Linguistics: Morphology and Syntax (3)

515. Medieval Spanish Literature (3)

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry.

528. Spanish Renaissance and Golden Age Prose (3) Various types of novels with special emphasis on the picaresque; didactic literature; histories.

535. Seminar in Renaissance and Golden Age Literature (3-6) Nature and development of Spanish literature of the 16th and 17th centuries; topics will vary.

537. Lope de Vega and Calderón (3) Major works of these and other dramatists of the Golden Age.

540. Cervantes and His Works (3)

543. Spanish Literature of the 18th Century (3) Didactic literature, poetry, drama, and novel in the most representative writers in the century.

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós.

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others.

563. Contemporary Drama in Spain (3) The drama since 1898, to the present day: Benavente, Valle Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others.

564. Twentieth Century Hispanic Literature (3-6) Principal trends and works after the Generation of 1898 and *modernismo;* topics will vary.

*A maximum of 7 credits in one summer.

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío.

580. History of the Spanish Essay (3) The principal essayists from the 16th century to the present.

585. Hispanic Poetry of the 19th and 20th Centuries (3) Various currents in the poetry of the Iberian peninsula and Latin America.

598. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature.

SPEECH

Robert E. Dunham, *Acting Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Professors Arnold, Holtzman, Nelson, Oliver, Schug, White, and Zelko; Associate Professors Brubaker, Dunham, Fife, and Phillips; Assistant Professors Brilhart and Olbricht.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

A thesis is required of all M.A. candidates in this major.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Schug*
402. General Semantics (3) *Mr. Phillips*
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Criticism (3) *Mr. Arnold*
415. Experimental and Applied Phonetics (3) *Mr. Brubaker*
417. Directing Forensics (3) *Mr. Dunham*
425. (Brcst. 425) Radio Programming and Performance (3) *Mr. Nelson*
431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Mr. Brubaker*
435. (Brcst. 435) Radio and Television Programming (3) *Mr. Nelson*
437. (Brcst. 437) Television Programming and Performance (3) *Mr. Hungerford*
450. Discussion: Research and Theory (2-6) *Mr. Phillips*
475. Studies in Mass Persuasion in the Democratic Society (3) *Mr. Hager*
476. Oriental Rhetoric and Contemporary Public Address in the Far East (2) *Mr. Oliver*
477. Contemporary Public Address: the Great Dictators (2) *Mr. Oliver*
478. Contemporary Public Address: English and American Speakers (2) *Mr. Gregg*

485. Advanced Oral Interpretation of Literature (3) *Mr. Hamilton*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*
494. Teaching of English as a Second Language (3) *Mr. Holtzman*
496. Speech for Teachers (3) *Mr. Grove*

500. Seminar in American Oratory (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Dunham*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech.

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Dunham*

520. Seminar in Speech Science (2-4) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Mr. Brubaker*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Holtzman*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Mr. Zelko*

555. Speech Communication: Problems and Principles (2-4) Prevalent theories of speech influence. *Messrs. Oliver and Phillips*

560. Public Address (2-4) Discussion and criticism of speech outline, manuscript, content, composition, and delivery. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Olbricht*

575. Research Problems in Speech (1-12) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology.

SPEECH PATHOLOGY AND AUDIOLOGY

Bruce M. Siegenthaler
In Charge of Graduate Programs in Speech Pathology and Audiology
2S Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors McDonald and Siegenthaler; Associate Professors Berlin and Frick; Assistant Professors Haspiel and Raabe.

Students may specialize in either speech pathology or audiology. Admission to study for the master's degree requires 27 credits in clinical speech and hearing, education, and psychology, including at least 9 in speech pathology and/or audiology and a course in statistics. The major is one of the areas of study within the Department of Special Education.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing

speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

STATISTICS

James B. Bartoo, *Head of the Department of Mathematics*
231 McAllister Building

Degrees Conferred: Ph.D., M.A., M.S.
Graduate Faculty: Professors Bartoo, Bennett, Griffiths, Patil, and Schipper; Associate Professors Harkness, Prokasy, and Starling; Assistant Professor Borden.

The modern science of mathematics and applied statistics is concerned with the general principles of dealing wisely with uncertainty and partial ignorance through mathematical probability.

To be admitted as a regular candidate for an M.A. or M.S. degree, the individual must possess an undergraduate degree with a background in mathematics including at least one and one-half years of calculus. Additional mathematical and statistical training is desirable. Admission to candidacy for the Ph.D. degree is granted only upon the recommendation of the faculty in statistics.

A Master of Arts in mathematical statistics requires 24 credits of course work and a thesis (6 credits) or 30 credits of course work and a term paper. A Master of Science in applied statistics requires 24 course credits and a thesis (6 credits).

In addition to meeting the Graduate School requirements for the doctorate, a candidate for a Ph.D. in statistics must pass written qualifying examinations in three fields. These are ordinarily probability theory, mathematical statistics, and mathematical analysis. Candidates must also complete at least 4 credits in algebra and 4 credits in topology, with at least 2 credits in each at the 500 level. Programs and qualifying examinations for a student specializing in another area of statistics must be approved by the faculty in general and specifically by the candidate's committee.

STATISTICS (STAT)

400. Intermediate Statistical Analysis (3)

409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)
411. Practicum (1)
418. (Math. 418) Introduction to Probability Theory (3)

501. Theory of Statistics (3) Sufficiency and completeness, testing hypotheses, sequential analysis, chi-square tests, analysis of variance. Prerequisite: Stat. 410.

502-503. Analysis of Variance and Regression (3 each) Linear hypotheses, regression, analysis of variance and covariance, mixed and random effects models, multiple comparisons, designs. Prerequisites: Stat. 410; Math. 441 or 481.

504. Nonparametric Statistics (3) Goodness-of-fit tests, contingency tables, analysis of multinomial and percentage data, multi-sample problems, special topics. Prerequisite: Stat. 410.

505. Multivariate Statistical Analysis (3) Statistical procedures associated with the multivariate normal distribution. Prerequisites: Stat. 410; Math. 441 or 481.

506. Sampling Theory (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

516. (Math. 516) Intermediate Probability Theory (3) Random walk and recurrent events, Markov chains, and the simplest time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) Advanced Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 501, Stat. 541.

541. (Math. 541) Mathematical Statistical Analysis (3) Probability spaces, random variables, distribution and characteristic functions, convergence theorems, univariate and multivariate distribution theory. Prerequisite: Math. 421.

542-543. (Math. 542-543) Advanced Theory of Statistics (3 each) Exact and asymptotic sampling distribution theory, rigorous treatment of sufficiency, completeness, estimation, and testing. Prerequisites: Stat. 410, 541.

577. (Math. 577) Special Topics in Probability and Statistics (3-12)

590. Seminar in Statistical Methods (1-6) Lectures on current statistical methods; presentation and discussion of literature treating various special topics in statistics.

THEATRE ARTS

Walter H. Walters, *Head of the Department*
103 Arts Building II

Degrees Conferred: M.A., M.F.A.
Graduate Faculty: Professors Neusbaum, Smith, and Walters; Associate Professors Reifsneider and Yeaton; Assistant Professor Allison.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.

The M.F.A. program is planned to provide a professional emphasis. Students will take a core program and specialize in performance (acting, directing), dramatic writing, or production (scene design, technical direction, stage lighting, stage costuming).

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

Requirements for admission to the M.A. program are a broad undergraduate preparation; one course each in basic acting, directing, theatre crafts, and history of the theatre, or their equivalents; and 12 credits divided among speech, music, art, and dramatic literature, or 9 credits in one of these fields.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, 3 of which must be in history of the theatre. In certain cases courses in speech, dramatic literature, art, music, dance, architecture, and other similar subjects may be accepted.

2. Auditions or submission of manuscripts, portfolios, photographs of theatre work, or other evidence of ability, according to specialization, as arranged by the student with the department.

All students in the M.A. and M.F.A. programs who lack the expected upper-class undergraduate courses in theatre may be requested to take additional course work without degree credit. All graduate majors are required to participate in University Theatre productions in positions of responsibility.

THEATRE ARTS (THEA)

404. Styles of Acting (3-6)
412. Advanced Scene Design (3-6)
413. Stage Lighting (3)
414. Stage Costuming (3)
415. Theatre Organization and Management (3)
421. Advanced Playwriting (3)
430. Ancient and Medieval Theatre (3)
431. Theatres of the Renaissance and the Orient (3)
432. History of the Modern Theatre (3)
433. Dance for the Theatre (3)
442. Creative Dramatics with Children (3)
443. Marionettes and Puppetry (3)
451. Directing (3-6)
452. Central Staging (3)
470. Theatre Production (1-6)
481. (Brcst. 481) Television Drama (3)
482. (Brcst. 482) Radio and Television Directing (3)

501. Directing (1-6 per term)

502. Technical Theory in Dramatic Production (3-6)

504. Styles of Acting (3-12)

506. The Contemporary Theatre (3-6)

507. Dramatic Theory (3-6)

512. Stage Design (1-6 per term)

521. Playwriting (3-12) Prerequisite: Thea. 421.

VOCATIONAL INDUSTRIAL EDUCATION

George L. Brandon
Head of the Department of Vocational Education
250 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Professors Brandon and Williams; Associate Professor Brantner.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial education is required for admission.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)
403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (4)
415v. Problems in Coordinating Vocational Education (3)
420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. Vocational Education for Administrators (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. Research in Vocational Education (3) Research techniques in vocational industrial education.

556v. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.

558v. State and Local Supervision and Administration (2-3) The more important recent problems in organization, supervision, and administration.

559v. Vocational Technical Education (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT

Bertil G. Anderson
Head of the Department of Zoology
208 Life Sciences Building

or

Robert E. McDermott
Head of the Department of Forestry and Wildlife
102 Forestry Building

Degree Conferred: M.S.

Graduate programs in the field of wildlife management are offered by the Department of Zoology for students primarily interested in the animal aspects, and by the Department of Forestry and Wildlife for those primarily interested in the habitat aspects.

ZOOLOGY

Bertil G. Anderson, *Head of the Department*
208 Life Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Professors Anderson, Anthony, Cheng, Cooper, Davis, Hale, Schein, and Wright; Associate Professors Bellis, Boyle, Grun, Houlihan, and Wood; Assistant Professors Butler, Lytle, and Wickersham.

Students may specialize in animal behavior, bioacoustics, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, parasitology, physiology, population dynamics, or wildlife management.

In order to undertake graduate work in zoology, students are required to have had 24 credits in zoology and related biological sciences; and they should have had calculus, physics, and chemistry through organic. A limited deficiency may be made up without degree credit while pursuing graduate work.

ZOOLOGY (ZOOL)

401.	(Pty.Sc. 401, Psy. 401) Animal Behavior (3)	*Mr. Hale*
403.	(Ent. 403) Systematics (3)	*Mr. Boyle*
405.	(Bot. 405) General Cytology (3)	*Mr. Grun*
408.	Mammalogy (4)	*Mr. Davis*
410.	General Limnology (3)	*Mr. Cooper*
415.	The Literature of Zoology (1)	*Mr. Anderson*
416.	The Methods of Research in Zoology (2)	*Mr. Anderson*
417.	Invertebrate Zoology (3)	
419.	General Animal Ecology (3)	*Mr. Bellis*
421.	Comparative Anatomy of Vertebrates (4)	
422.	(Bot. 422) Advanced Genetics (3)	*Mr. Wright*
437.	Histology (4)	*Mr. Anthony*
440.	Embryology (4)	

444. Zoological Problems (1-6)
448. Ornithology (3) *Mr. Wood*
450. Ichthyology (3) *Mr. Cooper*
461. Animal Parasitology (3)
471. Vertebrate Physiology (3)

505. (Bot. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Zool. 405 or 422. Spring term, odd years. *Mr. Grun*

509. Techniques in Wildlife Management (2) Evaluation of procedures designed to manage populations of game and fish; elements of statistics of birth and mortality rates; census methods. Fall term. *Mr. Davis*

512. Seminar (1) Review of current zoological literature. Required of graduate students majoring in zoology and entomology.

520. Special Topics (1-6)

524. (Bot. 524) Seminar in Genetics (1 per term) *Mr. Wright*

525. History of Biology (3) Historical development of biological knowledge and theories. Fall term.

528. (Bot. 528) Population Genetics (3) Factors affecting gene frequency, genotype frequency, genotype-environmental interaction, and genetic relationship in natural and artificial populations. Winter term, even years.

533. (Bot. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

537. (Bot. 537, Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term.

541. Cellular and Comparative Physiology (3) Basic functions of animal cells and their variations in the animal kingdom.

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term. *Mr. Davis*

551. Fisheries Management (3) Basic principles underlying management of inland waters for fish production. Summer term, even years. *Mr. Cooper*

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals.

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale, Schein, and Davis*

583. General Endocrinology (2) Anatomy and physiology of the organs of internal secretion; role of hormones in metabolism and development. Spring term, odd years. *Mr. Anthony*

587. Biology of Sex (2) Hereditary and embryological aspects, problems in gonadal differentiation, cyclic reproductive phenomena, actions of the hormones. Spring term, even years. *Mr. Anthony*

Other Elective Graduate Courses

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3) *Mr. Hicks*

THE ARTS (ARTS)

400. Contemporary Forms in Art, Music, Theatre (3)

ASTRONOMY (ASTRO)

430. General Astronomy for Teachers (3)
470. Solar Physics (3)
490-491. Introduction to Astrophysics (3 each)
495. Practical Astronomy (3)

510. Astrophysics (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. Astrophysics (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. Astrophysics (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussions of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

520. Galactic Structure (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

522. Spherical Astronomy (3) Astronomical coordinate systems, Kepler's equation, aberration, parallax, precession and nutation, time, eclipses and occultations, and solar motion.

525. Double Stars (3) Two-body theory; analysis of visual, astrometric, spectroscopic, and eclipsing binaries; and discussions of particular systems. Prerequisite: Astro. 522.

582. Radio Astronomy (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. Radio Astronomy (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

590. Special Topics (1-3 per term) Theoretical studies in any field of modern

astronomy or astrophysics, with or without associated experimental work. Prerequisites: Astro. 510, 511, 512.

BROADCASTING (BRCST)

425. (Spch. 425) Radio Programming and Performance (3) *Mr. Nelson*
435. (Spch. 435) Radio and Television Programming (3) *Mr. Nelson*
437. (Spch. 437) Television Programming and Performance (3) *Mr. Hungerford*
481. (Thea. 481) Television Drama (3)
482. (Thea. 482) Radio and Television Directing (3)
492. (Journ. 492) Public Affairs Broadcasting (3)

ENGINEERING (ENGR)

450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

511. Underwater Sound Propagation (4) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (4) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Modern Acoustic Signal Processing (4) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

531. Advanced Digital Computer Programming (3) Nonnumerical applications; symbol manipulation, syntactical analysis, and translation of artificial languages; heuristic methods, learning mechanisms, artificial intelligence.

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

FOOD TECHNOLOGY (FD T)

400. Effects of Processing on Food (3)
401. Sanitation and Quality Control (3)
402. The Thermal Process (1)

GREEK (GREEK)

421. Greek Tragedy (3)
422. Greek Comedy (3)

INSTRUCTIONAL MEDIA (INST M)

435. Orientation to Instructional Media (2)
436. Production and Utilization of Graphic Stimulus Materials (3)
437. Production of Educational Motion Pictures (3)
443. Television in Education (3)

531. Organization and Administration of Media in Schools (2) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 435.

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

598. Seminar in Italian Literature (3-12) Common and individual research in special problems.

LABOR-MANAGEMENT RELATIONS (L M R)

411. Trade Union Administration (3)
421. Labor Education (3)

LANDSCAPE ARCHITECTURE (L ARCH)

425-426. Landscape Construction Problems (3 each)	*Mr. Burggraf*
427. Landscape Construction Problems (2)	*Mr. Burggraf*
434. (Rc.Ed. 434) Recreation Areas and Facilities (3)	*Mr. Miller*
454-455-456. Landscape Design (3 each)	*Mr. Miller*
460-461-462. Advanced Landscape Design (4 each)	*Mr. Polakowski*
471. Park Design and Administration (2-4)	*Mr. Wilson*
472. Site Planning of Institutional and Public Projects (2)	*Mr. Miller*
473. Site Planning of Institutional and Public Projects (2)	*Mr. Miller*

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects. Prerequisite: L.Arch. 456.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LATIN (LATIN)

428. Lucretius (3)	*Mr. Krauss*
429. Quintilian (3)	*Mr. Prakken*
431. Juvenal (3)	*Mr. Krauss*
436. The Teaching of Latin (3)	*Mr. Krauss*

500. Latin Literature (3) Lectures and collateral readings on the major forms of Latin literature; readings in the original Latin to supplement the lectures. *Mr. Krauss*

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. *Mr. Krauss*

502. Latin Epigraphy (3) Lectures and readings on Roman inscriptions; illustrative exercises. *Mr. Prakken*

503. Latin Paleography (3) The Latin alphabet, writing materials, Roman book and cursive hands; illustrative exercises. *Mr. Prakken*

504. Roman Topography (3) Physical development of the city of Rome, its walls, aqueducts, bridges, streets, forums, public buildings, temples, etc.; building materials and methods of construction. *Mr. Prakken*

510. Latin Seminar (3) *Mr. Krauss*

518. Latin Research (1-3) Prosecution of an assigned problem under the guidance of a member of the department.

LIBRARY SCIENCE (L SC)

403. Intermediate Dictionary Cataloging and Subject Headings (3)
405. Intermediate Reference Work and Bibliography (3)

LINGUISTICS (LING)

500. Generative Linguistics (3) Types of grammatical rule and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

501. Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

502. Historical Linguistics (3) Principles of comparative linguistics; language families; reconstruction of phonemic, morphemic, and syntactic structures of extinct languages.

MINERAL SCIENCES (MN SC)

411. Instrument Techniques Applied to Mineral Science Problems (1-3)
421. X-ray Diffraction (3)

510. X-ray and Electron Diffraction Analysis as Applied to Minerals and Metals (2-4) Prerequisite: Mn.Sc. 421.

513. Semiconductor Physics (3) Electronic structure of solids; electronic transport phenomena; semiconductor materials; luminescence. Prerequisite: Phys. 400 or E.E. 32. *Mr. Henisch*

520. Electron Microscopy in Mineral Science Research (1-4) Prerequisite: Mn.Sc. 411, Unit B.

540. Solid State Structures and Reactions in Mineral Systems (2-4) Crystal chemical approach to solid state reactions, sintering, melting, hardness, thermal expansion, and behavior of matter under high pressure. *Mr. Weyl*

PORTUGUESE (PORT)

598. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems.

RELIGIOUS STUDIES (RL ST)

402. Contemporary Religious Thought (3)
430. Religion and Morality (3)
440. Problems in Religious Studies (3-6)

VETERINARY SCIENCE (V SC)

400. Veterinary Anatomy and Physiology (3)
401. Infectious Diseases of Domestic Animals (3)
420. General Animal Pathology (3)

515. (Micrb. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

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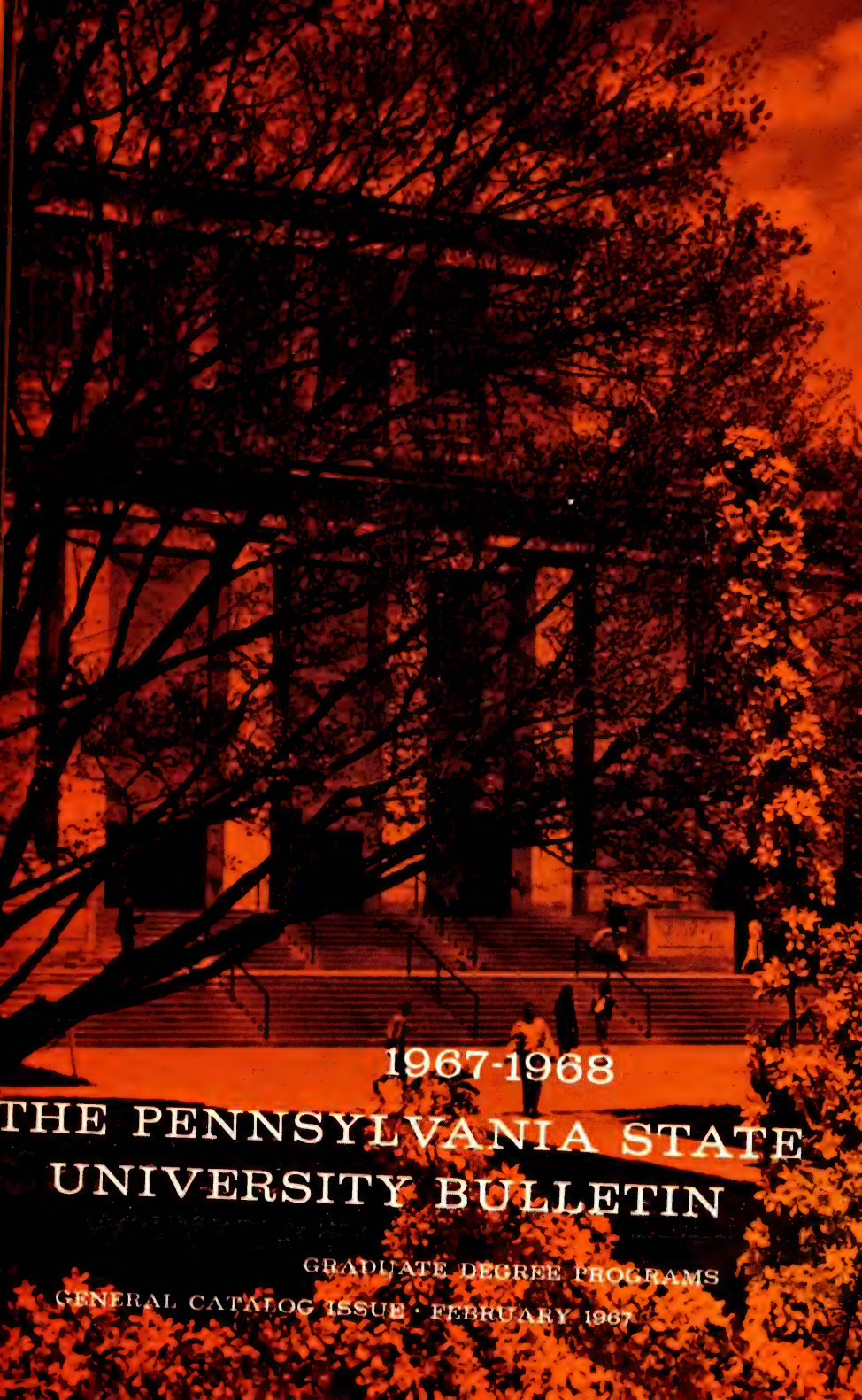
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1967-1968

THE PENNSYLVANIA STATE UNIVERSITY BULLETIN

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE · FEBRUARY 1967

OFFICES OF THE GRADUATE SCHOOL

M. Nelson McGeary, *Dean*

University Park Campus
101 Willard Building
University Park, Pa., 16802
Telephone: Area Code 814, 865-6323

A. Witt Hutchison, *Assistant Dean*

King of Prussia Graduate Center
Route 23 and Henderson Road
King of Prussia, Pa., 19406
Telephone: Area Code 215, 265-5400

John M. Schempf, *Assistant Dean*

Capitol Campus Graduate Center
P. O. Box 230
Middletown, Pa., 17057
Telephone: Area Code 717, 944-5571

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1967-1968

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE • FEBRUARY 1967

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*GRADUATE CALENDAR

WINTER TERM 1967

OVEMBER 1966

5 Saturday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1967

5 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1967

NUARY 1967

5-7 Thursday Noon to Saturday Noon—Winter Term Registration

5-7 Thursday Noon to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates

9 Monday—Winter Term Classes Begin 8 a.m.

9 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

17 Tuesday—Graduate Faculty Meeting

18 Wednesday—Last Date for Adding Courses to Approved Schedules

25 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

30 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates

EBRUARY

4 Saturday—Written French Language Examination for Advanced Degree Candidates

25 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

ARCH

4 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates

4 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

4 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally

11 Saturday a.m.—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Required Papers

11 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in March

18 Saturday—Winter Term Classes End 12:25 p.m.

20-22 Monday to Wednesday—Final Examinations

25 Saturday—Commencement

SPRING TERM 1967

NUARY 1967

30 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1967

30 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1967

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*This calendar was approved by the Board of Trustees. It is subject to change without notice. preparing the calendar for an academic year, the University makes every effort to avoid conflicts h religious holidays. However, such conflicts are sometimes unavoidable. When they occur, orts are made to make special arrangements for the students affected.

MARCH

30-31 Thursday p.m. and Friday—Spring Term Registration Begins
30-31 Thursday p.m. and Friday—Oral Examinations in Foreign Languages for Advanced Degree Candidates Begin

APRIL

1 Saturday a.m.—Spring Term Registration Continues
1 Saturday a.m.—Oral Examinations in Foreign Languages for Advanced Degree Candidates Continue
3 Monday—Spring Term Classes Begin 8 a.m.
3 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
12 Wednesday—Last Date for Adding Courses to Approved Schedules
15 Saturday—Written French Language Examination for Advanced Degree Candidates
18 Tuesday—Graduate Faculty Meeting
19 Wednesday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
24 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates

MAY

20 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
27 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
27 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser
27 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally

JUNE

3 Saturday a.m.—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
3 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in June
10 Saturday—Spring Term Classes End 12:25 p.m.
12-14 Monday to Wednesday—Final Examinations
17 Saturday—Commencement

SUMMER TERM 1967

APRIL 1967

20 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Summer Term 1967
20 Thursday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1967

JUNE

20-21 Tuesday p.m. and Wednesday—Summer Term Registration
20-21 Tuesday p.m. and Wednesday—Oral Examinations in Foreign Language for Advanced Degree Candidates
22 Thursday—Summer Term Classes Begin 8 a.m.
22 Thursday—Last Date for Registering with Foreign Language Departmen for Written Language Examinations

JULY

1 Saturday—Last Date for Adding Courses to Approved Schedules
†4 Tuesday—Independence Day Holiday
8 Saturday—Last Date for a September Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
17 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates
18 Tuesday—Graduate Faculty Meeting

AUGUST

5 Saturday—Written French Language Examination for Advanced Degree Candidates
5 Saturday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee
12 Saturday—Last Date for Final Oral Doctoral Examination for September Graduates
12 Saturday—Last Date for a September Graduate to Deliver Master's Thesis or Paper to Adviser
12 Saturday—Last Date for a September Graduate to Rent Cap, Gown, and Hood Locally
19 Saturday a.m.—Last Date for a September Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
19 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in September
†31 Thursday—Summer Term Classes End 9:55 p.m.

SEPTEMBER

1-2 Friday and Saturday—Final Examinations
3 Sunday Afternoon—Commencement

FALL TERM 1967

JULY 1967

21 Friday—Last Date for a Prospective Graduate Student to Apply for Admission to the Fall Term 1967
21 Friday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1967

SEPTEMBER

21-23 Thursday to Saturday Noon—Fall Term Registration
21-23 Thursday to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates
25 Monday—Fall Term Classes Begin 8 a.m.
25 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

OCTOBER

4 Wednesday—Last Date for Adding Courses to Approved Schedules
11 Wednesday—Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
16 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates
17 Tuesday—Graduate Faculty Meeting
28 Saturday—Written French Language Examination for Advanced Degree Candidates

†Classes which would have met on Tuesday, July 4, will meet according to schedule on Thursday, August 31, 1967.

NOVEMBER

11 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee
18 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates
18 Saturday—Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser
18 Saturday—Last Date for a December Graduate to Rent Cap, Gown, and Hood Locally
‡23 Thursday—Thanksgiving Day Holiday
25 Saturday a.m.—Last Date for a December Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
25 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in December

DECEMBER

‡4 Monday—Fall Term Classes End 9:55 p.m.
5-7 Tuesday to Thursday—Final Examinations
9 Saturday—Commencement

WINTER TERM 1968

NOVEMBER 1967

3 Friday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1968
3 Friday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1968

JANUARY 1968

4-6 Thursday Noon to Saturday Noon—Winter Term Registration
4-6 Thursday Noon to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates
8 Monday—Winter Term Classes Begin 8 a.m.
8 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
16 Tuesday—Graduate Faculty Meeting
17 Wednesday—Last Date for Adding Courses to Approved Schedules
24 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
29 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates

FEBRUARY

3 Saturday—Written French Language Examination for Advanced Degree Candidates
24 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee

MARCH

2 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
2 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

†Classes which would have met on Thursday, November 23, will meet according to schedule on Monday, December 4, 1967.

2 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally
9 Saturday a.m.—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
9 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in March
16 Saturday—Winter Term Classes End 12:25 p.m.
18-20 Monday to Wednesday—Final Examinations
23 Saturday—Commencement

SPRING TERM 1968

JANUARY 1968

29 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1968
29 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1968

MARCH

28-30 Thursday Noon to Saturday Noon—Spring Term Registration
28-30 Thursday Noon to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates

APRIL

1 Monday—Spring Term Classes Begin 8 a.m.
1 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
10 Wednesday—Last Date for Adding Courses to Approved Schedules
16 Tuesday—Graduate Faculty Meeting
17 Wednesday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
20 Saturday—Written French Language Examination for Advanced Degree Candidates
22 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates

MAY

18 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
25 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
25 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser
25 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally

JUNE

1 Saturday a.m.—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
1 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in June
8 Saturday—Spring Term Classes End 12:25 p.m.
10-12 Monday to Wednesday—Final Examinations
15 Saturday—Commencement

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Wilburn W. Newcomb, Ph.D. (Göttingen, Germany) — *Assistant Professor of Music*
H. Raymond Page, M.A. (Ohio State) — *Assistant Professor of Music*
William G. Pariseau, Ph.D. (Minnesota) — *Asst. Prof. of Mining Eng.*
Joseph Paternost, Ph.D. (Indiana) — *Assistant Professor of Slavic Languages*
Dante V. Scalzi, D.Ed. (Penn State) — *Asst. Prof. of Education*
Henry F. Schulte, Ph.D. (Illinois) — *Assoc. Prof. of Journalism*
H. Dennis Sherk, Ph.D. (Penn State) — *Assistant Professor of Education*
Charles J. Smith, M.S. (Carnegie Tech.), P.E. — *Assoc. Prof. of Civil Engineering*
Champ R. Storch, D.Ed. (Penn State) — *Asst. Prof. of Education*
Judith Stoyle, Ph.D. (Penn State) — *Associate Professor of Business Statistics*
Smith C. Toulson, III, M.Mus. (Yale) — *Asst. Prof. of Music*
Walter F. Westerfeld, M.S. (Penn State) — *Professor of Botany*

GENERAL INFORMATION

GRADUATE WORK at The Pennsylvania State University was first offered in 1862 when two graduate students were in residence. It was given more formal recognition in 1864 by the establishment of a "course for Graduates" designed for students who, after receiving the degree of Bachelor of Scientific Agriculture, wished to do advanced work leading to the degree of Master of Scientific Agriculture. For some time there were few graduate students, and graduate instruction was relatively unorganized. Later a committee of the University Senate was given the responsibility of establishing standards and regulations governing graduate work and the granting of advanced degrees. The Graduate School was organized in 1922. Until this time only masters' degrees and certain technical degrees had been conferred. In 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy. Still later other degrees were approved.

The faculty of the Graduate School consists of the President and certain other general administrative officers of the University, the Deans, the Librarian, the heads of departments, and those members of the instructional staff who have been authorized by the proper agencies of the Graduate School to offer graduate courses and supervise research leading to theses. It controls all academic matters pertaining to the Graduate School, subject to review by the University Senate. The Graduate Faculty has approximately 850 members.

During the academic year 1965-66, 3,400 to 3,600 graduate students were enrolled each term. In this interval, 1,223 advanced degrees were conferred, of which 258 were doctorates.

GRADUATE CENTERS—University Graduate Centers have been established in the Philadelphia and Harrisburg areas, and others are in the planning stage. Each of the two established centers operates under the immediate direction of a resident assistant dean of the Graduate School and is expected to have full-time resident faculty members in addition to part-time staff as quickly as justified by the enrollment. The programs to be offered in a Center will depend upon its location, the degree of interest, and the availability of qualified students in the immediate area.

The King of Prussia Graduate Center near Philadelphia, which opened in 1963, currently has an enrollment of more than 350 students. Its program leads to the degree of Master of Engineering with a major in Engineering Science.

The Graduate Center at Harrisburg, which opened in 1965 as the Susquehanna Valley Graduate Center, is now the Capitol Campus Graduate Center. Its enrollment is approaching 100. Programs leading to the degrees of Master of Engineering and Master of Administration are currently offered; others are in the planning stage.

Interested students are urged to write directly to the dean at the Center for information on programs and courses. Addresses are given on the inside of the front cover of this bulletin.

NEW MEDICAL CENTER—A gift of $50,000,000 from the Milton S. Hershey Foundation has made possible the establishment of a medical center near Harrisburg, Pennsylvania, for which facilities are now under construction. The first class of medical students is expected to enter in Fall, 1967. The program will emphasize medical research and operate in close cooperation with related departments on the University Park Campus.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at Penn State by scheduling relevant courses and research at University Park. Similarly a graduate student with an appropriate major at Penn State may earn credits at Jefferson which, upon advance approval by his major department, will be accepted in partial fulfillment of degree requirements at Penn State.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in this publication, the *Manual for Graduate Students,* and the *Thesis Information Bulletin,* and for meeting the standards and requirements expressed by these regulations. The *Manual,* which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Dean's office soon after admission.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not simply an extension of undergraduate work. It operates at a definitely higher level, demands scholarship of a high order, and emphasizes research and creativity. It involves a minimum of formal requirements and regulations, and a maximum of student initiative and responsibility.

A student does not become a graduate student merely by enrolling for advanced courses after having received a baccalaureate degree. Formal admission to the Graduate School is required.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number which can be accepted will vary with departments and from term to term. In some fields all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted. The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the resources of the University to provide graduate programs of outstanding quality.

Admission is granted by the Dean of the Graduate School after approval of the application by the department in which the student plans to do his major work. Blanks to be used in making formal application for admission can be obtained from the Graduate School office. In general, a student may begin his graduate work in fall, winter, spring, or summer. Prospective students may write directly to the head of any department concerning graduate work in that specific field.

Students from other countries are encouraged to write to the Director of International Student Affairs for information concerning finances, housing, and other non-academic matters.

CREDENTIALS—An applicant for admission should provide complete credentials, in duplicate, sent directly from other institutions to the Dean of the Graduate School at least two months prior to the opening of the term in which he plans to begin his graduate program. If the applicant has attended more than one institution, two official transcripts of the work covered at each institution are required. This applies to the complete academic record, both undergraduate and graduate.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements for an advanced degree.

UNQUALIFIED ADMISSION—For unqualified admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must have maintained during his junior and senior years a minimum grade point average equivalent to 2.5 on The Pennsylvania State University grading scale (approximately half B and half C). Finally, he must ordinarily have completed in a satisfactory manner a certain minimum of course

work in designated areas, the specific courses and amount of required work depending upon the field of advanced study which the student proposes to enter. The specific courses and the total number of undergraduate credits required can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. The minimum grade point average of 2.5 during the last two undergraduate years is a general requirement of the Graduate School. Individual departments may require a higher average for admission in their fields.

The above requirements apply particularly to the student who has recently completed an undergraduate program and is about to begin graduate study. An applicant who has done a year or more of graduate work in a recognized graduate school will be evaluated largely on the basis of the graduate record but with some attention to undergraduate achievement. For a mature person, recognized attainment in a professional field will be considered, and reduced weight will be given to old undergraduate records.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School and as a consequence will be required to cease attending any 500-level courses for which he may have registered. He may continue to attend courses below the 500 level provided he applies for and is accepted for registration as an adjunct student.

CONDITIONAL ADMISSION—When a department has space for additional students, an applicant whose grade point average is below 2.5 may be admitted conditionally for one term under the following circumstances: He must have had at least one year of significant experience after receiving the bachelor's degree and be recommended for admission by his major department. The applicant's credentials must be on file in the Graduate School office at least three months before the proposed date of registration. He must devote full time to his studies during the term for which he is conditionally admitted unless he is a student at one of the Graduate Centers or in a comparable situation where a full-time program is not available. In the latter case he may continue on a part-time basis until the equivalent of a full term has been completed. At the end of the student's first term (or equivalent first term in the case of a part-time student) his conditional admission will terminate. If an average grade of 3.0 has been earned, he may continue as a student with unqualified admission. If an average of 3.0 has not been attained, the student may not register again as a graduate student.

ADVISERS—To assist the student in planning his program, the head of his major department will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to make an appointment for an initial language proficiency interview at the Language Testing Center for International Students, 317 Sparks Building. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. Remedial work will be prescribed as indicated by the tests.

GUESTS OF THE UNIVERSITY—The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctors' degrees

who may be visiting the University for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses, and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade point average of 3). Any senior with a 3.5 grade point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400 and 500 series courses toward an advanced degree at Penn State. Upon admission to the Graduate School such credits as are relevant to the graduate field of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major and minor departments. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

STUDENT CONDUCT

The University expects that students will conduct themselves in accordance with the standards normally followed by educated men and women and in accordance with the laws of the Nation, State, and Borough. The right is reserved to sever at any time the University connection of any student whose influence is found to be injurious to the standard of morals and scholarship of the student body, or whose conduct is prejudicial to the good name of the University.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

CLASSIFICATION

At the time of admission to the University a student is classified as a graduate, adjunct, or undergraduate student depending upon his objectives and qualifications. A graduate student may be admitted either as a degree student or a non-degree student depending upon his objectives. After admission to one of these categories, any change to the other must be arranged through the Graduate School Office.

DEGREE STUDENTS—Persons who plan to become candidates for advanced degrees at The Pennsylvania State University and have been formally admitted for advanced study in a particular field are designated as degree students. The program of study is developed under the guidance of an adviser appointed by the head of the student's major department.

A degree student who has passed a candidacy evaluation is classified as a doctoral candidate.

NON-DEGREE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced

egree at this institution, may arrange for a program of work as a non-degree student. his classification includes those who plan to transfer credits to another institution nd those who plan a special program of study not leading to an advanced degree. he number of non-degree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of total enrollment. reference is given to students in degree programs.

If a non-degree student wishes to consult an adviser, one will be appointed upon equest to the department head most closely associated with the student's field of nterest. The student's status and standing will be reviewed by the Dean of the Graduate School at each registration. He may remain a non-degree student longer han one term only with the permission of the Dean, and for definite and good reasons.

ADJUNCT STUDENTS—An adjunct student is not a graduate student, inasmuch s he has not been admitted to the Graduate School, and may not register for graduate ourses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses, provided he has ttained at least junior standing in college.

Credits earned as an adjunct student may not ordinarily be applied subsequently oward an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least ntil he has met the minimum requirements for his degree, he must register for each erm in which he proposes to do either course work or research, or other work on his hesis, either on or off campus. In the case of research the number of credits shall be etermined by the amount of time required for the investigation, one credit representing one week of full-time graduate work.

CONTINUITY OF REGISTRATION—A student who registers at Penn State vithout interruption for each of the three terms in the interval September to June, or all four terms each year, or for each summer term is considered to have maintained normal continuity of registration. For the above purpose, it is immaterial whether he registration was for work at University Park, for off-campus research, or for courses ffered through Continuing Education.

Anyone who has interrupted such a normal sequence and now plans to register for vork at the University Park Campus is required to apply to the Dean of the Graduate chool at least two months before the time of registration for permission to resume tudy.

The policy may be summarized for any specific term as follows:

Summer Term—Application required unless the student was registered for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered for the preceding fall term.

Spring Term—Application required unless the student was registered for the preceding winter term.

PROCEDURE—For each registration the student, in consultation with his adviser, repares a schedule of courses and research designed to fit his individual needs. he credit load will be reviewed by the Dean of the Graduate School at the time of egistration. The registration process is completed in the manner specified for all udents at the University.

Under certain conditions credit may be earned by work done off the campus. A udent contemplating such work should inquire of the Dean of the Graduate School bout the procedures and conditions. The student must assume responsibility for

the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

EXCEPTIONS—When a candidate has met minimum requirements for a degree further registration shall be required only for course work, project work, and research work requiring the use of University facilities and supplies (including laboratory, library, and others). This means, for instance, that a student who has earned 90 credits in a doctoral program and has met all requirements for the degree except for the completion of his thesis and the passing of the final oral examination need not register for the additional research which may be required, whether it be done at University Park or elsewhere, provided he does not use University facilities or supplies. On the other hand, a student who uses University facilities or supplies for his research must be registered for credit at all times, regardless of the number of credits that may accrue before he completes his work. The same policy applies to masters' candidates.

A candidate need not register for the term at the end of which the degree is to be conferred solely for the purpose of graduating. He will, of course, be required to register if he has a significant amount of work to complete unless relieved of this obligation by the previous paragraph. He will not be required to register if he has only minor revisions of his thesis to complete and/or the final oral examination to pass.

TIME OF REGISTRATION—Registration days are indicated in the calendar on pages 3 to 7 of this bulletin.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control the student may be granted permission by his instructors to miss a few class meetings it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the amount of time which he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

LOADS, ACADEMIC AND EMPLOYMENT—Many students depend upon part time employment to help meet their expenses. A student who is thus employed however, must recognize the time demands of his work schedule in planning his academic program.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their Graduate School experience to a maximum extent. Therefore the Graduate School reserves the right to deny admission or registration to part-time students who (a) propose schedules of few credits which seem to reflect little real interest in graduate work or would not seem to require serious effort, or (b) wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality in their graduate work.

"Doing graduate work" means more than doing what is required in courses or in research. It means living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Overloads make it difficult and often impossible to do graduate work so conceived. Hence the following "protective" schedule of permitted loads for employed students has been adopted:

EMPLOYMENT	ACADEMIC LOAD
0 hours per week	8-10 credits allowed
10 hours per week	7- 9 credits allowed
20 hours per week	5- 7 credits allowed
30 hours per week	4- 5 credits allowed
40 hours per week	1- 4 credits allowed

This means, for example, that anyone working 20 hours per week (about half-time) whether as a half-time graduate assistant, as an employee on campus, or as an employee off-campus, will be limited in the amount of graduate work for which he may register to about three fifths of a normal full-time load (i.e., to 5-7 credits). The word employment is used in a very general sense and includes working for indirect compensation, such as housekeeping, working in the family business, maintaining a large vegetable garden, etc. Hence, all students who are thus employed will be expected to adjust their academic loads accordingly. Exceptions, in the case of students who have demonstrated unusual ability, must be arranged with the Dean of the Graduate School at the time of registration. (See also Visiting and Auditing Classes.)

A student holding a fellowship, graduate assistantship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no grade and cannot subsequently secure credit for work done in the course.

A student who, because of his status as a graduate assistant or fellow, is required to register for a certain minimum number of credits is not permitted to count those courses for which he is registering as an auditor for this purpose. The 1G and 2G language courses are an exception. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for the course as an auditor.

In the 1G and 2G courses offered by the language departments, visiting is not permitted and no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the language, he will be required to count the course as a part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

SELECTIVE SERVICE—A request for deferment must be addressed to the local board by the student himself. Although the University cannot make this request, it can supply local boards wih information needed in support of a request for deferment.

To have his local board informed of his formal admission to the Graduate School, a student must supply the essential Selective Service information and request the Associate Registrar to inform the board.

To have his local board informed of his registration and status as a student, a new graduate student must request the Associate Registrar to so inform the local board. If so requested, a report will be sent shortly after the beginning of the first term for

which the student registers. A student is certified to be a full-time student insofar a Selective Service is concerned if he schedules at least 8 credits (auditing a cours does not count), or if he holds an appointment as a quarter-time or half-time gradu ate assistant, or if he is serving an internship or holding a traineeship under approve conditions.

If at any time a student changes his status from full-time to part-time, fails t make satisfactory progress, or makes a drastic change in his declared goal, his loca board will be notified. If a student changes his status from part-time to full-tim and wishes the local board to be informed, he must request the Associate Registra to do so. When a student receives a master's degree, it will be assumed his progran is terminated, and his board will be so informed unless there is clear prior indicatio in the Registrar's Office of the student's intention of proceeding with a doctora program.

At the end of each spring term the Registrar's office reports to the local board the status of all graduate students for whom a report was made during one of th three previous terms.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student' scholarly attainment.

The following revised grading system is now in effect: Any one of five qualit grades (A, B, C, D, F) may be given a graduate student for course work or fo thesis research. The grade point equivalents are 4, 3, 2, 1, 0 respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credi whereas D and F are failing grades for graduate students, D being the normal failin grade. A grade of F indicates doubt in the judgment of the instructor of the student' potential for further graduate study.

A minimum grade point average of 3.0 for work done at this University is require for graduation in the case of all candidates whose first registration for graduate stud at this University occurred in the Spring Term 1964 or later.

In addition to the quality grades listed above, two symbols, "deferred" and R, ma appear on a student's transcript. If work is incomplete at the end of a term for reason beyond the student's control, or if very little work remains to be done, th instructor may report "deferred" in place of a grade, which will appear temporaril on the student's record.

In the case of thesis work, either in progress or completed, and certain course approved by the University Senate, the instructor may report the symbol R in plac of a grade. This symbol indicates that the student has devoted an adequate amoun of time to the work scheduled but gives no indication of its quality. An R remain on the student's transcript permanently. If, after having submitted a series of symbols, the instructor reports a grade of A, B, C, D, or F for a specific term, thi grade is considered to apply to the preceding series of registrations and to denot the quality of that entire series.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his in tention to graduate (by filing a diploma card or, if a diploma card is already on fil by requesting that it now be transferred to the active file), and to pay thesis fees the beginning of the term in which he expects to receive an advanced degree. Dea lines are given in the calendar on pages 3 to 7 of this bulletin.

See the *Manual for Graduate Students* for a detailed statement of procedure co cerning graduation. Attendance at commencement exercises is expected, but pe mission to receive the degree in absentia may be granted by the Dean of the Gradua School.

All degrees conferred are tentative until final grade reports have been receiv even though the student's name may have appeared in the commencement progra

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus—8 or more credits, total charge of $150 for Pennsylvanians and $350 for non-Pennsylvanians; 7 or fewer credits, $16 per credit for Pennsylvanians and $44 per credit for non-Pennsylvanians. These rates also apply to off-campus research and other approved individual study.

Graduate and Continuing Education Centers—8 or more credits, total charge of $130 for Pennsylvanians and $350 for non-Pennsylvanians; 7 or fewer credits, $14 per credit for Pennsylvanians and $44 per credit for non-Pennsylvanians.

Vocational Education Programs—7 or fewer credits, $22 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether taken as an auditor or for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than 10 days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Director of Admissions for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile of the one admitted (or of his parents, if he is a minor) within the Commonwealth for a period of at least 12 months immediately preceding the date of such petition for reclassification; and, in addition, such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following the twelfth month after such change has taken place.

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor not later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES—In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Admission to the Graduate School	$ 10.00
Change of schedule, each change	2.00
French reading examination	6.00
Music, individual lessons	30.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00

Thesis binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Transcript of records (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

A graduate student planning to operate a motor vehicle in the State College area should secure a copy of the leaflet *Parking and Traffic Regulations* from the Traffic Violations Officer, Room 203D, Hetzel Union Building.

TAXES—Depending upon their residence classification and appointment status, graduate students may be subject to taxes while at the University. In general, graduate assistants will be liable for the federal income tax and the State College borough wage tax on their stipends. A graduate student who is classified as a resident of one of the civil subdivisions of Centre County may also be subject to local taxes, including school tax. Details are given in the *Manual for Graduate Students.*

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fire-resistant, one-story, steel framework buildings. Forty-six one-bedroom units rent for $75 per month and 32 two-bedroom units rent for $85. The rent includes utilities except for electricity. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle, opened in 1960, has 144 one-bedroom and 72 two-bedroom apartments in 16 two-story buildings of brick and frame construction. The units rent for $82.50 and $92.50 per month, including all utilities. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator, and each bedroom has a built-in chest of drawers; otherwise the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age or with children who will become school age during the term of the lease cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children. An application form for a Married Student Apartment may be obtained by writing to the Department of Housing and Food Services, Assignment Office, 23 Pollock Hall, University Park, Pa., 16802. Telephone: Area Code 814, 865-7501.

Atherton Hall, located near the Hetzel Union Building and reserved exclusively for single graduate men and women, provides residence hall room accommodations without food service. Double, single, or single occupancy of double rooms are

available at $125, $140, and $150 per term respectively. The Hetzel Union Building cafeteria and snack bar are available for meals.

Separate dining hall meal tickets for one of eight campus dining halls may be purchased for $175 per term. Twenty-one meals per week are served beginning with registration and ending with final examinations.

For other information on the residence or dining halls, contact the Assignment Office, 23 Pollock Hall, University Park, Pa., 16802; telephone Area Code 814, 865-7501.

Information on other living accommodations available in the community may be obtained through the Chamber of Commerce, 129 W. Beaver Ave., State College, Pa., 16801; telephone Area Code 814, 237-7644. The cost of apartments or rooms in private homes or lodging houses varies considerably depending upon the type of accommodations desired, and arrangements can best be made by personal visit to the area.

Prospective graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be very difficult to find convenient housing at the last minute.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

STATEMENT OF NON-DISCRIMINATION

In the selection of individuals for all types of financial aids for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of the race, creed, color, or national origin of any applicant.

ASSISTANTSHIPS

Approximately 1,500 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some departments. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department for information and application forms. Appointments are made upon the recommendation of the department head, subject to admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship requires a continuing demonstration of good scholarship.

The assistantships vary as follows:

Quarter-Time—The student may schedule 7-9 credits, receives a stipend in the range $270-$480 plus a grant-in-aid which covers tuition, will be required to give a maximum of 10 hours of service per week for 12 weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

Half-Time—The student may schedule 5-7 credits, receives a stipend in the range $480-$1,020 plus a grant-in-aid which covers tuition, will be required to give a maximum of 20 hours of service per week for 12 weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

Three-Quarter-Time—The student may schedule 4-5 credits, receives a stipend

in the range $810-$1,350 plus a grant-in-aid which covers tuition, will be required to give a maximum of 30 hours of service per week for 12 weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by arrangement with the Dean of the Graduate School, provided the credit load and the service load are properly balanced in each term, and the total credit load over a series of terms is in conformity with the specified limits.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term without service if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an extra earned grant-in-aid form from the head of the department in which he has held the assistantship and must follow the instructions on the form in making application.

A graduate assistant may not accept employment, either at the University or elsewhere, during the period for which service to the University is required under the appointment (12 weeks per term).

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than 500 fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows and trainees carry a full-time graduate program, receive a stipend which varies with the award, and usually receive a grant-in-aid paid by the donor of the award to provide for all tuition. They may not accept employment during the term of their appointment (except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

GRADUATE SCHOOL FELLOWSHIPS—Eleven fellowships, each paying a stipend of $2,000 for the fall, winter, and spring terms, and providing a grant-in-aid to cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding advanced graduate students in any field, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences. An applicant must have completed at least one full year of graduate study prior to beginning the fellowship tenure and be a candidate for the doctoral degree.

Applications should be addressed to the Dean of the Graduate School and must be received by February 15 to be considered for the following fall, winter, and spring.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES—At least 230 such awards, with various stipends, are granted through individual departments. Information and application forms may be secured from the head of the major department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1965-66:

Accountants Fund, Inc., Dissertation Fellowship—Open to Ph.D. candidate in business administration who are preparing to teach accounting; stipend variable up to $5,000.

Amelia Earhart Fellowship—Available to women graduate students in aerospace engineering; stipend $2,400.

American Chemical Society Fellowship—Open to graduate students in chemistry and chemical engineering; stipend $1,800-$2,400.

American Chemical Society Fellowship—Open to graduate students in fuel science; stipend $2,280.

American Chemical Society Fellowships (2)—Open to graduate students in geochemistry, mineralogy, and solid state technology; stipend $2,400.

American Chemical Society Fellowship—Open to graduate students in geology; stipend $2,400.

American Cyanamid Fellowship in Chemistry—Open to graduate students in chemistry for the final year of study leading to the Ph.D. degree; stipend $1,800.

American Iron and Steel Institute Fellowships (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400.

American Petroleum Institute Fellowships (5)—Open to graduate students in chemistry and physics for research concerning the synthesis and properties of high molecular weight hydrocarbons; stipend $1,710-$2,280.

Armstrong Doctoral Fellowship in Business Administration—Open to Ph.D. candidates in business administration; stipend $3,100.

Armstrong Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry; stipend $640.

Atomic Energy Commission Graduate Traineeships in Nuclear Reactor Operations and Utilization (5)—Available to graduate students in nuclear engineering. Stipends comparable to the AEC Special Fellowships.

Carborundum Corporation Fellowship—Available to a graduate student in mineral preparation; stipend $2,400.

Continental Oil Company Fellowship—Available to graduate students in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

Continental Oil Company Fellowship in Petroleum Economics—Available to a graduate student in mineral economics for studies in petroleum economics; stipend $2,280.

Diamond Alkali Company Foundation Summer Fellowship—Open to a graduate student in chemical engineering; stipend $600.

du Pont Fellowship in Mechanical Engineering—Open to a graduate student in mechanical engineering; stipend $2,400.

du Pont Summer Fellowships (6)—Open to graduate students in chemical engineering; stipend $300-$600.

Esso Research and Engineering Fellowship in Chemistry and Chemical Engineering—Open to advanced graduate students for one year of study leading to the Ph.D. degree; stipend $1,800-$2,200.

W. S. Elliott Fellowship—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

Ford Motor Company Fellowship—Open to a graduate student in mechanical engineering; stipend $2,400.

General Electric Foundation Fellowship—Open to graduate students in chemical engineering; stipend $2,500.

General Foods Fund Fellowships (2)—For graduate work with a major in human development; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

General Telephone and Electronics Foundation Fellowship—Available to a graduate student in electrical engineering; stipend $3,000.

Gulf Oil Company Fellowship in Petroleum and Natural Gas Engineering—For graduate work in petroleum production; stipend $2,400.

Hamilton Standard Fellowship—Open to graduates of this University in aerospace, electrical, and mechanical engineering, engineering mechanics, and physics; stipend $1,800.

H. R. Imbt Services, Inc., Fellowship—For graduate work in civil engineering in the field of civil engineering construction; stipend $2,400.

International Business Machines Corporation Fellowship—Open to an outstanding advanced graduate student in the humanities or social sciences when his doctoral research is amenable to treatment by a digital computer; stipend $1,800-$2,500. Apply to the Dean of the Graduate School.

International Lead Zinc Research Organization Fellowship—In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Open to a student in ceramic science; stipend $2,400.

International Lead Zinc Research Organization Fellowship—In support of research on the physics and chemistry of lead and zinc compounds. Open to students in solid state technology; stipend $2,540.

Marathon Oil Company Fellowship—Available to graduate students in petroleum and natural gas engineering; stipend $2,280.

Monsanto Summer Research Fellowships (2)—Open to graduate students in chemistry; stipend $650.

National Lead Company, Titanium Alloy Manufacturing Division Fellowship—In support of research on the chemistry and physics of titanium and zirconium compounds of interest to the chemical and ceramic industries; stipend $2,600.

National Steel Corporation Fellowship—Available to a graduate student in metallurgy; stipend $2,880.

Edward Orton, Jr., Ceramic Foundation Fellowship—Open to a student in ceramic science for studies relating to kiln-fired ceramic materials; stipend $2,400.

Owens-Corning Fiberglas Fellowship in Ceramic Science—Open to a graduate student in ceramic science; stipend $3,000.

Owens-Illinois Fellowship—Open to a graduate student in ceramic science for studies in glass science and technology; stipend $3,000.

Pennsylvania Cooperative Fishery Unit Fellowships (3-4)—Available to graduate students in zoology; stipend $2,400-$2,460.

Pennsylvania Cooperative Wildlife Research Unit Fellowships (4)—Available to graduate students in forestry, zoology, and related fields; stipend $2,400.

Pennsylvania Electric Association Fellowship—For graduate work in mineral economics on potential markets for fly ash; stipend $2,400.

Pennsylvania Natural Gas Men's Fellowship—For graduate work in petroleum and natural gas engineering for studies in gas technology; stipend $2,000.

Radio Corporation of America Fellowship—Open to graduate students in electrical engineering; stipend $2,100-$3,000.

Shell Companies Foundation Fellowships (2)—Open to advanced graduate students in two of these fields in rotation: chemical engineering, chemistry, and petroleum engineering; stipend $2,000-$3,000.

Socony-Mobil Fellowship—Available to a graduate student in chemical engineering; stipend $1,500-$3,000.

Speer Carbon Fellowship—Open to graduate students in fuel science for studies on carbon; stipend $2,400.

Sprague Electric Company Fellowship—Open to students in ceramic science and solid state technology; stipend $2,400.

Stackpole Carbon Fellowship—Open to a graduate student in fuel science for studies on carbon; stipend $2,808.

Stackpole Ferrite Fellowship—Open to students in ceramic science and solid state technology; stipend $3,000.

Stauffer Chemical Company Fellowship in Chemistry—Open to a graduate student in chemistry for research on organometallic compounds; stipend $1,800.

Sun Oil Company Fellowship in Chemistry—Open to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

Texaco Fellowship in Geophysics—Available to a graduate student in geophysics; stipend $2,760.

Union Carbide Summer Fellowships (4)—Open to graduate students in chemical engineering; stipend $300-$600.

U. S. Office of Education Fellowships in Education of Exceptional Children (8)—Open to graduate students being prepared as leadership personnel in the education of the mentally retarded; stipend $2,000-$2,800 plus dependency allowance. Apply to the Head of the Department of Special Education.

U. S. Office of Education Fellowships in Speech Pathology and Audiology: Work with the Speech-Handicapped (5); Work with the Hard-of-Hearing (4)—Open to graduate students specializing in these fields; stipend $2,000-$2,800 plus dependency allowance. Apply to the Director of the Speech and Hearing Clinic.

U. S. Office of Education Traineeships in Educational Psychology (6)—Open to graduate students majoring in educational psychology and preparing for careers as educational research workers; stipend $2,400-$2,800 plus dependency allowance.

U. S. Public Health Service Traineeships in Clinical Psychology (12)—Open to selected graduate students in this area of psychology; stipend $1,800-$3,000.

U. S. Public Health Service Traineeships in Microbiology—Open to selected graduate students in microbiology; stipend $2,400-$2,800.

U. S. Public Health Service Traineeships in Public Health Nutrition—Open to selected graduate students in foods and nutrition; stipend $3,000.

U. S. Public Health Service Traineeships in Sanitary Engineering—Open to graduate students in sanitary engineering; stipend $3,600-$5,000.

U. S. Public Health Service Traineeships in Zoology (4)—Open to selected graduate students in zoology; stipend $2,400-$2,760.

United States Steel Foundation Fellowship—Open to graduate students in the College of Earth and Mineral Sciences for studies related to steel-making; stipend $2,880.

U. S. Vocational Rehabilitation Administration Traineeships in Speech Pathology and Audiology (11)—Open to graduate students majoring in speech pathology and audiology; stipend $2,400-$2,800.

U. S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in Counselor Education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (18)—Open to selected advanced graduate students in this area of psychology.

Walter Thomas Memorial Scholarship—Open to students studying the nutrition of horticultural crops; stipend variable.

In addition, numerous grants are available from governmental agencies, industrial concerns, and foundations for the support of investigations of particular problems. Many of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS

—Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. See statement on non-discrimination, p. 39.)

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelors' degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a

participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Associated Universities, Oak Ridge, Tennessee. About 200 will be awarded.

National Aeronautics and Space Administration Predoctoral Traineeships in Space-Related Science—The National Aeronautics and Space Administration awards training grants to various recognized universities to increase the supply of scientists and engineers in space-related science and technology in order to meet the growing needs of the federal government's space research program. These grants permit a university to award a specified number of traineeships in science and engineering fields. The awards compare favorably with the best fellowships. In 1966-67 the University had 42 of these traineeships in physical science and engineering fields. More may be available for 1967-68. No institution will know whether it has any available until late in the fall. Applicants should write to the graduate dean at the institution of their choice, or to the head of the department in their graduate field. More than 1,200 were awarded in 1966.

National Defense Graduate Fellowships—Under Title IV of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education makes an allotment of three-year fellowships to approved institutions which have applied for them and designates the major fields among which the awards may be distributed. One purpose of these awards is to assist able graduate students who certify their interest in college or university teaching to obtain their doctorates, thus increasing the higher education teaching staff nationally. The program also aims to increase the development and utilization of doctoral degree training facilities and promote their wider distribution geographically.

Seventy-five per cent of these fellowships in an institution must be awarded to students with no more than one-half year of graduate study by September; the remainder may be awarded to those who have completed no more than two years of graduate study by September. These awards compare favorably with the best fellowships available. The University had 142 students studying under these fellowships in 33 different fields of the arts and sciences in 1966-67.

No institution knows until the fall of each year whether it will have any additional fellowships under this program for the following year. A senior or an interested graduate student should inquire from the head of his actual or anticipated graduate major department. Applications will be made directly to the departments or graduate deans of institutions having programs in the desired field. Most institutions have application deadlines from February 15 to 20. Approximately 6,000 of these fellowships will be awarded for 1967-68.

National Defense Modern Foreign Language Fellowships—Under Title VI of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

Late in the fall the Commissioner of Education announces the institutions, the quotas of fellowships, and the specific language and area programs to which the fellowships are allocated. (For 1966 the announcement was made December 1, 1965.)

In 1966-67 the University had a few in Russian language and area studies. A few may be available for 1967-68 in this program only. Write to the Head of the Depart-

ment of Slavic Languages, 127 Sackett Building.
Approximately 1,300 were awarded for 1966-67.

National Science Foundation Graduate Fellowships—The Graduate School cooperates in this program of prestige fellowships, requiring outstanding credentials, and available in the biological, engineering, mathematical, and physical sciences, anthropology, economics (excluding business administration), geography, history and philosophy of science, political science, psychology (excluding clinical), and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, and meteorology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N.W., Washington, D. C., 20418, which has charge of evaluating applicants for the Foundation. The application deadline for 1967-68 was December 9, 1966; about 1,100 new awards were to be made for that year.

National Science Foundation Graduate Traineeships—This program was expanded for 1966-67 to include all the areas supported by the Graduate Fellowship Program mentioned above. The National Science Foundation awards training grants to various recognized universities to accelerate the output of graduate students in these fields and to help meet the Nation's future needs for scientific and professional manpower. These grants permit a university to award a specified number of traineeships, 80 per cent of which must go to first-year graduate students. These awards compare favorably with the best fellowships. In 1966-67 the University had 69 of these traineeships distributed through 32 areas supported by NSF. More will probably be available in many of the areas for 1967-68. No institution will know until the middle of January whether it will have any available. Applicants should write to the graduate dean at the institution of their choice, or to the head of the department in their graduate field. About 2,100 new awards will be made for 1967-68.

National Science Foundation Science Faculty Fellowships—These awards are made to enhance the effectiveness of college faculty members who have at least three years' experience as full-time staff members teaching science, mathematics, or engineering mainly to undergraduates. They are awarded to those working for a Ph.D., or to those holding the degree and teaching in any of the fields supported by the NSF Graduate Fellowship Program. Tenure may be from 3 to 15 months and can be spread over three successive summers. For information write to the National Science Foundation, Washington, D.C., 20550. The application deadline for 1967-68 was October 10, 1966; about 250 awards are being made.

Study Fellowships for International Development—The Inter-University Committee on Study Fellowships for International Development, supported by a grant from the Ford Foundation, makes these awards for one year of graduate study, usually toward the master's degree, to United States and Canadian citizens under 35 years of age who have served in a volunteer capacity for more than one year in one of the developing countries and wish to devote a significant portion of their careers to overseas development assistance. Fields of study include such areas as agriculture, business administration, community development, economics, engineering, English (to be taught as a second language), political science, public administration, and public health. The universities cooperating in this program are U.C.L.A., Chicago, Columbia, Cornell, Harvard, North Carolina, Oregon, Penn State, Stanford, Teachers College (Columbia), and Wisconsin. About 70 fellowships will be awarded for 1967-68. Applications may be obtained from the central office for the program: Study Fellowships for International Development, 115 Sackett Building, The Pennsylvania State University, University Park, Pa., 16802; or from overseas representatives of the Peace Corps. Completed applications for 1967-68 were required to be received at the above address before February 6, 1967.

U. S. Public Health Service Predoctoral Fellowships—Available to graduate students in anatomy, anthropology, behavioral sciences, biochemistry, biomedical engineering, biophysical sciences, biostatistics, botany, developmental biology, endocrinology, entomology, genetics, history of life sciences, medicinal chemistry, microbiology, nursing, nutrition, organic chemistry, pathology, pharmacology, physiology, social and psychological sciences, zoology, and air and water pollution. These fellowships are used at the university of one's choice and are more frequently awarded to second or third year graduate students. Prior to formal application a senior must have been admitted to a graduate school and must have obtained a sponsor there who will supervise his training. Application should be made to the Career Development Review Branch, Division of Research Grants, National Institutes of Health, Bethesda, Maryland, 20014, by October 1 for awards announced in February, by January 1 for June awards, and by April 1 for September awards. Approximately 2,000 will be awarded for 1967-68.

Woodrow Wilson National Fellowships—Awarded by the Woodrow Wilson National Fellowship Foundation for first-year graduate study at the institution of one's choice, to outstanding students who show a clear preference for a career in college teaching, especially in the areas of the humanities and social sciences. Science and mathematics majors will be considered; but they must also apply for a National Science Foundation Fellowship, and if it is received, they must accept it in preference to the Woodrow Wilson award. Students must be nominated by a professor in their undergraduate college. The nomination is sent to the regional representative of the Woodrow Wilson Fellowships for the area in which that college is located. Interested students should consult the dean or other official of their college, or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J. Nominations must reach the regional chairman by October 31, each year. Approximately 1,000 fellowships are awarded.

OTHER AIDS

COUNSELORSHIPS FOR MEN—A number of appointments are available to men graduate students to serve as Resident Counselors in the undergraduate residence halls for men. A counselor's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training and experience in personnel work are desirable, though not essential.

These appointments are for three terms (fall, winter, and spring). Remuneration is in the form of room, board, and exemption from the additional out-of-state tuition, if applicable. In addition, a grant-in-aid for full tuition is available to a limited number of the Resident Counselors selected. A counselor may not hold a fellowship or assistantship during the term of his appointment as a counselor. He may not engage in any other form of part-time employment. He may carry 7 to 9 credits per term.

Requests for information and application forms should be addressed to the Dean of Men, 117 Old Main.

SENIOR RESIDENT POSITIONS FOR WOMEN—Full-time salaried appointments as Senior Residents in undergraduate halls for women are available to qualified women graduate students. Responsibilities include working with student groups in a programming capacity, counseling, and supervising the residence hall during the evening. Preference is given to persons working for a master's degree in higher education, specializing in student personnel administration.

These positions permit the holders to take 4 graduate credits per term at reduced tuition. Appointments are made for the fall, winter, and spring terms. Special arrangements of hours of work and credits may be made for the summer term. It is thus possible to complete work for a master's degree in two calendar years.

Requests for information and application forms should be addressed to the Dean of Women, 111 Old Main.

GRADUATE GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on the basis of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed 10 hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $150 per term, to non-Pennsylvanians, $350 per term. A few grants are available for students beginning graduate study in the winter or spring term, if applications are filed six weeks before registration for that term.

Applications should be addressed to the Dean of the Graduate School and must be received by March 15 to be considered for the following summer or fall.

DU PONT TEACHING AWARD IN CHEMISTRY—To be eligible for the E. I. du Pont de Nemours and Company Postgraduate Teaching Assistant Award, a graduate student must be currently serving as a part-time teaching assistant and preferably should have had two years of experience in this capacity. The recipient receives $1,200 in addition to the regular stipend paid him as a teaching assistant.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP—Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is $1,500 for a tenure of three terms plus a grant-in-aid for tuition.

JOHN W. WHITE FELLOWSHIPS—Awarded to two or three graduates of The Pennsylvania State University each year on the basis of scholarship, need, character, and aptitude. The recipients may enroll in any approved college or university. Application is made to the Office of Student Aid, Grange Building.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded annually through individual departments. A request for information should be directed to the department head in the field of the student's major interest.

A.A.U.W. SCHOLARSHIP—The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

LOANS ADMINISTERED BY THE UNIVERSITY—The Director of the Office of Student Aid has charge of all loans administered by the University, for both undergraduate and graduate students. Application forms may be obtained from his office, Grange Building. Funds are available from three sources:

University Loan Funds have been established through the generosity of University organizations, alumni, faculty, staff, and friends. Graduate students without assistantships who are registered for a full credit load may obtain long-term loans, while graduate assistants who are classified as full-time students by the Dean of the Graduate School may qualify for only short-term loans from these funds. Applicants must demonstrate a need for financial assistance in meeting University-related expenses and be United States citizens, except that international students may qualify for short-term loans if they can secure a responsible resident of Pennsylvania as cosigner of the note. The interest on long-term loans does not begin until after graduation and generally is at a low rate for the first two years.

National Defense Education Act Loan Funds are available for United States citizens from the Federal Government, this act having been expanded in the fall of 1964,

to increase the amount allotted to each institution and to increase the ceiling on loans to graduate students to $2,500 per year. The forgiveness of half the loan over a five-year period for those entering teaching has been extended to college teaching and to teaching in private elementary and secondary schools, as well as to teaching in public elementary and secondary schools. Interest at 3 per cent does not start until one year after the borrower ceases to be a full-time student. Repayment in 10 annual installments then begins. Of course, repayment may be made sooner if desired.

The Alumni Graduate Student Loan Fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School alumni who have received their bachelor's degrees elsewhere. The Graduate Student Association has also made sizable contributions to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and microfilming fee, job interview travel, etc. Students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

STATE HIGHER EDUCATION LOAN PLANS—A number of states have passed laws which enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in those states to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for those who have been residents of Pennsylvania for one year prior to filing an application and are accepted for enrollment in an approved institution of higher education. A full-time graduate student may borrow up to $1,000 per year, the total not to exceed $7,500 during the entire period of his post-secondary education. To be eligible, a part-time graduate student must be enrolled for at least 6 credits and is limited to $500 per year. The Federal government will generally pay the interest on behalf of the student while he/she is enrolled in school and the first 3 per cent of interest while the student is making repayment following graduation or withdrawal from school. Repayment of the principal of the loan is not required until the student leaves or graduates from school. Generally, to be eligible for the interest subsidy, the annual adjusted family income must be below $15,000 per year and the student must be enrolled in an eligible course of study in a non-profit institution. A list of participating lending institutions is available from all secondary school counselors, school financial aid officers, or the Pennsylvania Higher Education Assistance Agency, Guarantee Loan Program, Towne House, Harrisburg, Pennsylvania, 17102.

Residents of other states should inquire from their State Education Departments regarding the existence of similar plans. Practically all the states of the United States and the District of Columbia have such programs.

ASSURED EDUCATION PLAN—The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his 68th and 61st birthdays respectively. Payments are handled through the Girard Trust Bank, Philadelphia, Pa. Further information and application forms may be obtained from the Office of the University Bursar, 3 Willard Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly.

A student who holds a graduate assistantship, fellowship, or traineeship may not accept employment, either at the University or elsewhere, during the period of his appointment, except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs.

The Office of Student Aid, Grange Building, offers assistance to students in finding part-time employment in town as well as on the campus.

VETERANS BENEFITS—The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws.

Under P. L. 89-358, a student is classified as full-time if he registers for 8 or more credits, or if he holds a half-time or quarter-time graduate assistantship.

STUDENT SERVICES

HEALTH CENTER—The services at the Ritenour Health Center are available to graduate students registered for 8 or more credits and to all graduate assistants, fellows, and other holders of graduate tuition grants.

Eligible students are entitled to five days' treatment in the University Hospital at $10 per day each term. For each day of confinement in excess of five days, a charge of $15 is made. A charge will be made for all drugs dispensed as required for treatment, and a charge may be made for dispensary visits or emergency treatment. Consult the *Manual for Graduate Students* for details concerning facilities and services.

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY—The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general educational work of the University.

Therefore any student who desires insurance protection while in attendance at the University (1) against personal injury and/or (2) against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

HEALTH INSURANCE PLAN—A voluntary Accident and Sickness Insurance Plan with a variety of benefits is available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center. The Undergraduate Student Government, which operates the plan, has offices in Room 203A Hetzel Union Building, University Park, Pa., 16802. Telephone: Area Code 814, 865-4952.

PLACEMENT SERVICE—The University Placement Service, in cooperation with all the Colleges and departments of the University, assists both graduate and undergraduate students in finding appropriate employment upon graduation. In addition, services are extended to alumni. Several services are offered: (1) career counseling concerning career planning, career opportunities, employer characteristics, and employment trends; (2) a library of information about employers, employment trends, and career opportunities; (3) the scheduling of interviews with employers visiting the campus; (4) an extended file of employment opportunities for which a student may apply by mail; (5) a listing of summer jobs and internships appropriate to the student's career interests; and (6) conducting of appropriate research. These services are closely coordinated with the Division of Counseling.

Contact is maintained with several thousand employers in education, industry, and government. Information concerning employment opportunities is routinely distributed to all academic departments.

The general placement section concentrates on employment possibilities in industry and government. The teacher placement section concentrates on administrative, teaching, and service opportunities in universities as well as in elementary and secondary schools.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths serve the student body. Many other religious organizations, including denominational and interdenominational groups, are active on the campus and in association with local churches.

STUDENT AFFAIRS—The Graduate Student Association is the official University-wide organization of graduate students. All students have membership in the Association, which promotes the general welfare and the academic interests of graduate students. It publishes the *Graduate School Newsletter*, helps to sponsor the Graduate School lecture series, and sponsors social functions.

MASTERS' DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees: academic and professional. Of the eleven masters' degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forestry, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE POINT AVERAGE—A minimum grade point average of 3.0 for work done at this University is required for graduation in the case of all candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION—In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the field in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of field and can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. An applicant who meets the minimum grade point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the minimum period of residence. An applicant for admission to the M.Ed. program in most major fields is required to have had at least 18 credits in education and related psychology, and in certain major fields may be required to have had practice teaching.

After a student has been admitted to a degree program, he should confer with the head of his major department concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department in which the stu-

dent is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department.

TRANSFER CREDIT—Subject to the limitations given below on the use of credits earned away from the University Park Campus, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. When transfer credits are accepted at the time of admission, the student is not really assured of their applicability in his program until he has consulted his adviser and the details of his graduate program have been worked out.

M.A. AND M.S.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus. A candidate must present a major and either a minor field of study or an approved group of general studies. A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to but different from that of the major. A general studies group consists of no fewer than 6 credits in fields other than that designated as the major field and considered by the major department to have significance and value for the candidate.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major field. A thesis is required of all candidates for the degree of Master of Science and of most candidates for the degree of Master of Arts. Details are given in the introductory paragraphs under the major field headings in the latter part of this bulletin. If a student is required to write a thesis, he must complete at least 6 credits of thesis research (600 or 610).

Those candidates who are not required to write a thesis must present a suitable essay or term paper. Its nature and extent shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The department may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off-campus. To do so he must make satisfactory arrangements in advance with his adviser and the head of his major department.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

M.ADM.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Administration are designed to meet the professional needs of practicing and potential administrators. A basic premise is that administration is a necessary function of all organizations and that it embodies a common body of knowledge and skills regardless of its area of application. These

programs should be sharply distinguished from the research-oriented programs which lead to the academic degree of Master of Science in such majors as business administration, educational administration, and others.

The programs require a minimum of 30 graduate credits with at least 18 in core courses and 12 in the area of specialization, with the greater portion of the courses being at the 500 level.

Each student is required to complete a research project in the field or a laboratory in which he applies research methods and tests his solution through experimentation or simulation. The report must have the quality but need not have the depth of theoretical development of a graduate thesis.

After substantially completing his course requirements, a candidate must pass a comprehensive written and oral examination to be administered by a committee composed of graduate faculty members. The candidate will be expected to demonstrate his ability to integrate the knowledge gained in specialized areas with that gained in the broad general area of administration.

M.Agr.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Agriculture have a professional orientation and provide training for increased competence in the various fields of agriculture. They should be clearly distinguished from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which at least 12 must be in 500-level courses and the remainder in 400-level courses. A minimum of 20 credits must be earned on the University Park Campus and at least 12 must be earned outside the candidate's major field.

In addition to credit requirements, a candidate must present a paper on a selected professional problem comparable in quality to a thesis in which he applies scientific methods to the solution of a problem. He must demonstrate ability to (a) formulate and state meaningfully the problem and objectives, (b) critically analyze the present state of knowledge of the problem, (c) acquire and analyze information to help solve the problem, (d) draw logical conclusions, and (e) interpret the relationship between the findings and professional problems. The paper will be evaluated by a committee appointed by the Dean of the Graduate School.

The candidate is required to pass a final examination administered by a committee of three faculty members appointed by the Dean of the Graduate School with at least one member from a department other than that of the candidate's major field.

M.B.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Business Administration are designed to develop advanced professional competence in the various fields of business administration. They should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Science and Doctor of Philosophy with a major in Business Administration.

The programs require a minimum of 36 graduate credits of which at least 18 must be at the 500 level and at least 26 must be earned on the University Park Campus. Candidates who enter this program without undergraduate training in business administration may be required to take up to 21 credits of preparatory courses.

Moreover, a candidate is required to present a project paper, comparable in quality and scope of work to a graduate thesis, concerning a problem of a company.

After substantially completing his course requirements, a candidate must pass a comprehensive examination to be administered by a committee composed of graduate faculty members, the first part being written and the second part oral. During these examinations the candidate will be expected to demonstrate his ability to integrate the knowledge gained in the several functional areas of business in a manner which

reflects a broad knowledge of his professional responsibilities.

Applicants for the various graduate programs in business administration are required to take the Admission Test for Graduate Study in Business given by the Educational Testing Service.

M.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the several fields of education. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. In most major fields the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned on the University Park Campus and at least 24 must be in course work.

At least 15 credits in 500 series courses is required except in those fields for which the Dean has approved the waiving of this requirement for an experimental period of five years.

MAJORS IN THE FIELDS OF EDUCATION—A student may major in one of the approved fields of education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate department of education.

A program of this type requires at least 6 credits to be earned outside the fields of education.

MAJORS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German, may choose such a field as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose such a major as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology. However, if his educational foundations background is judged to be adequate, the candidate may be approved for work in any field of education.

THESIS OR PAPER—Six credits may be granted for an approved thesis. Those candidates who do not elect to write a thesis are required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department to require one or more copies of such an essay for its library or other files.

M.Eng.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should

be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required of which at least 12 must be earned in graduate courses (500 series), and at least 6 must be earned outside the candidate's field of concentration.

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

M.F.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in Art, Music, or Theatre Arts.

A minimum of 48 credits is required of which at least 38 must be earned on the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Forestry provide training for increased professional competence in the several specialized areas of forest resource management and forest products. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science with a major in forestry.

A minimum of 30 graduate credits is required of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.P.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration at local, state, national, and international levels or with private and voluntary agencies. This program should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may also specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required of which at least 6 must be devoted to either a thesis or an internship. Students with extensive government experience will write a thesis; others will serve an internship and write a critical review of the experience, the review to be comparable in quality to a thesis. A comprehensive final examination will be required of all students, the examination to be written, oral, or both.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervising committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

The degree is a terminal one and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

M.R.P.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, the maintenance of cultural and aesthetic values, and the legal and governmental techniques for their implementation.

A minimum of 45 graduate credits is required of which at least 35 must be earned on the University Park Campus. At least 36 credits are required in planning courses of which 9 will be devoted to a group regional planning project or a problem-oriented thesis. Students who do not submit a thesis will present a project report, comparable in quality and scope to a graduate thesis.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred. The two programs are recognized as different in purpose and consequently have different requirements in certain respects.

ADMISSION—A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major field in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department and is given near the end of the first, or at the beginning of the second, year of graduate work including that done for the master's degree and work done elsewhere as well as here (i.e., at about the time he has earned a total of 30 graduate credits).

A new student transferring from another graduate school with 30 or more transfer credits must take this examination before he has earned more than 10 credits here.

There are no specific admission requirements in education and related psychology for the degree of Doctor of Education unless specified by the department or committee in charge of the particular major field. When such requirements do exist, they are listed in the introductory paragraphs under the major field headings in the latter part of this bulletin.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure the attainment of the doctorate. The general requirements are based upon a period of residence, the passing of comprehensive examinations, and the writing of a satisfactory thesis. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE POINT AVERAGE—A minimum grade point average of 3.0 for work done at this University is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later.

TIME LIMITATION—A student who was formally accepted as a doctoral candidate on or after June 1, 1963, is required to complete his program within seven years from the date of his acceptance as a candidate. A student who was admitted to doctoral candidacy, formally or informally, prior to June 1, 1963, is required to complete his program before July 1, 1971.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research, or their equivalent in credits, is required for a doctor's degree. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study. The D.Ed. candidate may meet the residence requirement by enrollment in the summer terms, but increasingly departments are insisting upon the same requirements as for the Ph.D.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term and three such terms will meet the minimum residence requirement for the Ph.D.

OFF-CAMPUS AND TRANSFER CREDITS—Subject to the approval of his adviser and the head of his major department, a student may register for research to be done away from the University Park Campus. Such work will not be approved simply because the arrangement is convenient for the student; scholarly considerations must determine the choice of location. A doctoral candidate may register for a maximum of 30 credits of research in absentia but none of these may count toward the minimum of 30 credits which he is required to earn on the University Park Campus. The maximum load permitted a student who is employed full time is 4 credits in a term.

With the approval of his committee, a candidate may apply toward the minimum requirements of a doctor's degree a maximum of 10 credits earned in Continuing Education classes or at the Commonwealth Campuses of The Pennsylvania State University. Credits so earned as a part of a master's degree program must be included in the limit of 10.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major field may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major field may be accepted here to apply toward doctoral degree requirements. Work beyond the master's will not be transferred if taken more than five years before beginning work for the doctorate at Penn State. Credits transferred will apply toward meeting degree requirements only if judged by the doctoral committee to be appropriate to the candidate's program of study. In practice, it is rarely possible for a candidate who has the maximum number of transfer credits to complete the requirements in an additional year. Sequential requirements in courses and ex-

aminations, special departmental requirements, and the possibility of protracted research are likely to extend the time needed; the quality of the program rather than the time requirement is of paramount concern.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted to a degree program, he should confer with the head of his major department concerning departmental procedures and the appointment of an adviser. The arrangement and approval of the details of the term-by-term schedule of the student is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major department for this specific duty.

The general guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of five or more members of the Graduate Faculty. The committee is appointed by the Dean of the Graduate School, upon recommendation of the head of the major department, after the student is admitted to candidacy. The chairman of the committee must hold senior membership in the Graduate Faculty. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. At his discretion, the Dean may add other members to the committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after admission to candidacy. The committee will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

LANGUAGE EXAMINATIONS—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School and must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must show either a reading knowledge of two other languages or general competence in one other language. The languages used to satisfy this requirement must have significance in the candidate's field of study and be approved by the candidate's doctoral committee and the Dean of the Graduate School. French, German, and Russian are the languages most frequently needed and will be approved by the Dean without specific request. The use of any other language must be approved in advance.

If a candidate elects to be examined for a reading knowledge in two languages, he is urged to complete one-half of the requirement before admission to candidacy and is required to complete the whole requirement before taking the comprehensive examination. The candidate must report his intention to take the examination in reading competence to the secretary of the language department concerned during the registration period for any term during which he wishes to take it. The examination will be administered on dates announced in the graduate calendar at the beginning of this bulletin.

The reading competence option may be satisfied by the achievement of at least a grade of B in the second (2G) of two courses specifically designed for developing reading ability if a language department desires to use such a course in that way.

If the candidate elects to demonstrate a general competence in one language—i.e., the ability to communicate effectively—he is required to demonstrate competence in reading as described above before applying for examination in the remaining skills. The remaining skills will be tested at a time and place designated by the language department concerned before the candidate may take the comprehensive examination.

In general, the language requirements must be met at this University. However, if a student has passed suitable language proficiency examinations at another institution prior to admission to the Graduate School at Penn State, this may be accepted in satisfaction of requirements here.

Candidates for the D.Ed. degree may be required by their major departments to demonstrate competency in foreign languages, but there is no Graduate School requirement.

COMPREHENSIVE EXAMINATIONS—When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major and minor fields of study.

A candidate for the Ph.D. must have satisfied the language requirements before taking the examination.

All candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later are required to have a minimum grade point average of 3.0 for work done at this University at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. The comprehensive examination is given and evaluated by the doctoral committee and may be either written or oral, or both. A favorable vote of at least two thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School.

In no case may the final oral examination be scheduled less than three months after the comprehensive examination.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATIONS—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. In no case may the final examination be scheduled less than three months after the comprehensive examination. The deadline for holding the examination is three weeks before Commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the whole field of study of the candidate without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

MINOR FIELDS—A minor is not required of all candidates for the Ph.D. degree. A department or a committee in charge of a major field may require a candidate

to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and the minor fields.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal on the part of the candidate an ability to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than two weeks prior to the Commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate, such as biological science, foods and nutrition, or English.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) the satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

MAJOR AND MINOR FIELDS—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major field of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education.

A candidate choosing a major in one of the fields of education must also choose either a minor or a group of general studies with the approval of the major department. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside the fields of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside the fields of education considered by the major department to have significance and value for the candidate.

COMPREHENSIVE EXAMINATIONS—In addition to demonstrating a high level of competence in the subject matter of his major and minor fields, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he

is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at this University occurred in the Spring Term 1964 or later are required to have a minimum grade point average of 3.0, for work done at this University, at the time the comprehensive examination is given.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. The thesis may be based upon a product or project of a professional nature, provided that scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than two weeks prior to the Commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

PROGRAMS AND COURSES

Programs of study leading to advanced degrees are offered in many major and minor fields. These are listed in the following section, and the major fields are summarized at the beginning of the following section. Related courses are grouped together under the name of the field. To locate a particular course or group of courses, consult the index.

In general, departments of the University are identified with specific major fields. Thus aerospace engineering is a major field of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, biological science and comparative literature are major fields for which there are no corresponding departments. In such cases a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one field. Thus the Department of Civil Engineering offers work in both civil and sanitary engineering.

Applicants for admission are encouraged to consult the person whose name is listed under the major field heading.

DEGREES—In those major fields approved for the doctorate, the Ph.D. is normally conferred, although a program leading to the D.Ed. may also be arranged with the consent of the department or committee in charge if such a professional program is appropriate. Similarly, in major fields approved for the master's degree the M.A. or M.S. is normally conferred, but a program leading to the M.Agr., M.B.A., M.Ed., M.Eng., M.F.A., or M.F. may also be available. The D.Ed. and M.Ed. are not limited to the fields of education, but with the consent of the department or

committee in charge may be offered in any approved major field appropriate to the preparation of teachers, such as mathematics or English. In this case the program is sponsored by a major department outside the fields of education, such as the Department of Mathematics, but the student's minor is in education.

MINOR FIELDS—All major fields listed are also acceptable as minors, subject to the approval of the proposed minor department. In addition, a few fields in which no advanced degrees are offered have been approved as minors for candidates who are majoring in related areas. Such minor fields are identified in the summary at the beginning of the following section and by a brief statement under the field heading in that section.

A candidate's choice of minor field depends upon the particular degree he is seeking and is subject to the approval of both his major and minor departments. The requirements in each minor field are established by the minor department subject to the regulations of the Graduate Faculty.

INTERDISCIPLINARY MAJORS—In addition to the majors listed on the following pages, interdisciplinary majors involving two or more departments may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental committees.

OTHER FIELDS—Fields which have not been approved for either major or minor work, but in which approved courses are offered, are listed at the end of this bulletin. These courses may be used in graduate programs as electives or as part of a general studies program, subject to the approval of the major department and to the restrictions upon the use of 400 series courses in degree programs.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 50 to 55 under the specific requirements for the various masters' degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.5, and other students who have been granted permission to enroll by the Dean of the Graduate School.

Course numbers 600 and 610 apply to thesis research and are available only to students registered in the Graduate School.

CREDITS—A credit is defined as a unit of time approximately equivalent to one week of full-time graduate study. Accordingly, a full-time student having no concurrent employment may earn a maximum of 10 credits in a 10-week term. A "credit" as used in this bulletin, therefore, is identical in meaning with a "semester credit" and should not be confused with a "quarter credit" which is associated with the traditional quarter system. By increasing the length of class periods to 75 minutes, the Penn State calendar based upon a 10-week term provides for the same amount of time in a given course as does the typical semester plan.

COURSE DESCRIPTIONS—A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department offering the course.

A department may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400 and 500 series courses a department may schedule an individual student for fewer credits than the maximum number but in no case for more than the maximum number authorized.

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes,* which is available at nominal cost from the Scheduling Office approximately six months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

RESEARCH AND THESIS WORK—In general, students registering for work on a master's or a doctor's thesis will, if it is to be done on the University Park Campus, use course number 600 preceded by an abbreviation designating the major field. Thus Nuc.E. 600 signifies thesis research in nuclear engineering. In case such work has been authorized for students not working on the University Park Campus, the number 610 will be used. Credits will be 1 to 10 per term.

It should be assumed that the number 600 and 610 are available in all fields in which majors have been approved for advanced degrees although these numbers may not appear in the *Schedule of Classes.*

MAJOR and MINOR FIELDS

GRADUATE FIELDS OF STUDY

Administration—M.Adm.
Aerospace Engineering—Ph.D., M.S.
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—M.S.
Agronomy—Ph.D., M.S., M.Agr.
Animal Industry—Ph.D., M.S.
Animal Nutrition—Ph.D., M.S.
Anthropology—Ph.D., M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A., M.F.A.
Art Education—Ph.D., D.Ed., M.S., M.Ed.
Art History—Ph.D., M.A.
Astronomy—Ph.D., M.S.
Biochemistry—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Business Education—Ph.D., D.Ed., M.S., M.Ed.
Ceramic Science—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S.
Chemistry—Ph.D., M.S.
Child Development and Family Relationships—Ph.D., D.Ed., M.S., M.Ed.
Civil Engineering—Ph.D., M.S., M.Eng.
Clothing and Textiles—Ph.D., D.Ed., M.S., M.Ed.
Comparative Literature—Ph.D., M.A.
Computer Science—Ph.D., M.S.
Counselor Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Earth Sciences—M.Ed.
Economics—Ph.D., M.A.
Education of Exceptional Children—Ph.D., D.Ed., M.S., M.Ed.
Educational Administration—Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology—Ph.D., M.S.
Electrical Engineering—Ph.D., M.S., M.Eng.*
Elementary Education—Ph.D., D.Ed., M.S., M.Ed.
Engineering Acoustics—Ph.D., M.S.
Engineering Mechanics—Ph.D., M.S., M.Eng.
Engineering Science—M.Eng.*
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S., M.Agr.
Extension Education—M.Agr., M.Ed.
Family Economics and Home Management—Ph.D., D.Ed., M.S., M.Ed.
Food Service and Housing Administration—M.S., M.Ed.
Foods and Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Forestry—M.S., M.F.
French—Ph.D., M.A.
Fuel Science—Ph.D., M.S.
General Engineering—M.Ed., M.Eng.
General Family Studies—M.S., M.Ed.
Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed., M.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Art (minor only)
Home Economics Education—Ph.D., D.Ed., M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—M.S., M.Eng.
Journalism—M.A.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Preparation—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S.
Music—M.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
Physiology—Ph.D., M.S.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., D.Ed., M.S.
Public Administration—M.P.A.
Recreation and Parks—M.S., M.Ed.
Regional Planning—M.R.P.
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
School Psychology—D.Ed., M.S., M.Ed.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
Solid State Technology—Ph.D., M.S.
Spanish—Ph.D., D.Ed., M.A., M.Ed.
Speech—Ph.D., D.Ed., M.A., M.Ed.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics—Ph.D., M.A., M.S.
Theatre Arts—M.A., M.F.A.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

The degrees listed above are the ones normally conferred in each of the designated major fields. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above fields in which a master's degree is conferred provided the field is appropriate to the preparation of teachers.

*Not offered on the University Park Campus.

Courses in Major and Minor Fields

ADMINISTRATION

Rocco Carzo, Jr.
Chairman of the Committee on the Master of Administration Degree
207B Boucke Building

Degree Conferred: M.Adm.

Programs leading to the degree of Master of Administration are offered only at the Capitol Campus in Harrisburg. All candidates take a core program but may concentrate in some area of specialization through elective courses. Emphasis may be placed on business administration, engineering administration, or logistics administration.

Admission requirements include a knowledge of differential and integral calculus, micro- and macroeconomic analysis, and statistical inference.

AEROSPACE ENGINEERING

George F. Wislicenus, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Lumley, McCormick, and Wislicenus; Associate Professors Holl, Hoult, and Sevik. Associate Members—Assistant Professors Lakshminarayana and Tennekes.

Opportunities are available for graduate study in the following and related areas: modern fluid mechanics and physics, the interaction of fluids with solids, and the application of these disciplines to the design of devices and to the environment in which they operate. These topics are specifically included: cavitation, magnetohydrodynamics, rarified gas dynamics, the stability of laminar motions, turbulence, aero- and hydroelasticity, stability and control of vehicles, turbomachinery, V/STOL aircraft, high lift devices, and ground effect machines.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so.

AERONAUTICAL ENGINEERING (ARO E)

401a,b,c. Aeronautical Engineering Projects (2-12)
402. Aerospace Design (2)
407. Aerodynamics of V/STOL Aircraft (3)
410. Aircraft and Space Propulsion (3)
411. Aeroelasticity (3)
412. Turbulent Flow (3)
413. Stability and Control of Aircraft and Missiles (3)
415. Free Molecular Flow and Radiative Heat Transfer (3-6)

416-417. Aerospace Undergraduate Thesis (2 each)
418. Aerospace Systems Engineering (3)
420. Principles of Flight Testing (3)
425. Theory of Flight (3)

503. Electromagnetically and Chemically Active Flows (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. Aerodynamics of V/STOL Aircraft (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aro.E. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Perfect Fluid Theory A (3) Mathematical review, equations of motion and general consequences, application of complex variables to two-dimensional flow, conformal representations, Stokes' stream function.

509. Perfect Fluid Theory B (3) Review of axisymmetric motion; two-dimensional vortex motions; motions with cylindrical, spherical geometry; Bessel, Legendre functions; vortex motions in space. Prerequisite: Aro.E. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory. Prandtl-Meyer flow, method of characteristics.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

518. Aircraft and Missile Dynamics (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, re-entry, stability and control, and automatic control. Prerequisite: Aro.E. 413.

520. Selected Topics in Aeronautical Engineering (1-12)

AGRICULTURAL ECONOMICS

MACKLIN E. JOHN
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Senior Members—Professors Barr, Becker, Bennett, Brandow, Butz, Frey, Hutton, McAlexander, Pasto, Pierce, Southworth, and Trotter; Associate Professor Stemberger. Associate Members—Assistant Professors Hallberg, Herrmann, Jansma, and Schutjer.

The graduate program emphasizes economic theory and analytical techniques in conjunction with concentration in farm management, production economics, agricultural marketing, resource economics, agricultural policy and prices, or international agricultural trade and development.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

AGRICULTURAL ECONOMICS (AG EC)

407. ADVANCED FARM MANAGEMENT (3) *Mr. Hutton*
410. AGRICULTURAL FINANCE AND APPRAISAL (3)
420. AGRICULTURAL PRICES (3) *Mr. Bennett*
421. LAND ECONOMICS (3) *Mr. Frey*
422. LAND AND WATER RESOURCE POLICY (3) *Mr. Jansma*
450. INTERNATIONAL AGRICULTURAL TRADE AND DEVELOPMENT (3) *Mr. Schutjer*
460. INDUSTRIAL ORGANIZATION IN FOOD PROCESSING AND DISTRIBUTION (3) *Mr. Hallberg*
461. DECISION-MAKING IN AGRICULTURAL MARKETING FIRMS (3) *Mr. Stemberger*

500. SEMINAR IN AGRICULTURAL ECONOMICS (1-6) Review of current literature and problems.

504. SEMINAR IN AGRICULTURAL POLICY (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy-making. Prerequisites: Ag.Ec. 420, Econ. 405. *Mr. Brandow*

505. ADVANCED AGRICULTURAL STATISTICS (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. SEMINAR IN FARM MANAGEMENT (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

514. SURVEY RESEARCH TECHNIQUES IN AGRICULTURAL ECONOMICS (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400.

515. ECONOMIC PROBLEMS IN THE MARKETING OF DAIRY PRODUCTS (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. *Mr. Brandow*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences.

527. Seminar in Applied Quantitative Methods (1-4)

534. Agricultural Production Economics (3) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change. *Mr. McAlexander*

535. Seminar in Agricultural Marketing (2) *Mr. Southworth*

541. Economic Organization of Agriculture (3) Agriculture as a sector of the total economy; changes in markets, resources, internal structure, and income; interregional competition.

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods. *Mr. Herrmann*

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use.

AGRICULTURAL EDUCATION

David R. McClay, *Head of the Department*
101 Agricultural Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Member—Professor Stevens. Associate Members—Professor McClay; Associate Professors Anthony, Hoover, and Love.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, business, or in general studies. Programs may include courses needed for certification in other fields of education.

AGRICULTURAL EDUCATION (AG ED)

418v. Survey of Vocational Education in Agriculture (1-4)
420v. Instructional Media in Agriculture (1-6)
422v. Supervision of Vocational Education in Agriculture (1-4)
424v. Occupational Guidance in Agricultural Industry (1-4)
426v. Adult Education in Agriculture (1-4)
434v. Agricultural Developments (1-6)

501v. Agricultural Education in the United States (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. Teaching Agriculture (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation.

504v. Agricultural Education Seminar (1 per term)

508v. Administration and Supervision of Agricultural Education (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. Teacher Education in Agriculture (1-6) Organization and administration of university programs of teacher education in agriculture, including pre-service preparation, continuing education, research, and other services.

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. Program Development in Agricultural Education (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, technique of teaching, and measurements of results of teaching.

AGRICULTURAL ENGINEERING

Frank W. Peikert, *Head of the Department*
204 Agricultural Engineering Building

Degree Conferred: M.S.
Graduate Faculty: Senior Members—Professors Mohsenin and Peikert. Associate Members—Professors Bartlett and Stephenson; Associate Professors Aldrich and Kjelgaard.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; and rural sanitation and conservation engineering.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, solar poultry houses and plant growth structures for modified atmosphere, and a laboratory for research on mechanical and rheological properties of agricultural materials. This laboratory is equipped with an Instron testing machine with a complete line of accessories including an environmental chamber and the Instron Rheometer for research on rheology of foods and agricultural materials.

Prerequisite to major work is the completion of an undergraduate major in engineering.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Agricultural Structures (3)
404. Agricultural Machinery (3)
405. Agricultural Process Engineering (3)
406. Advanced Dairy Engineering (3)
407. Soil Water Engineering (3)
408. Instrumentation for Agricultural Production and Processing (3)
409. Agricultural Systems Engineering (3)
410. Agricultural Power (3)
420. Seminar (1)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY

Walter I. Thomas, *Head of the Department*
118 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Senior Members—Professors Fortmann, Hunter, Kardos, Matelski, Richer, Robinson, Thomas, and Washko; Associate Professors Baker, Cleveland, Duich, McKee, and Starling. Associate Members—Professor Raleigh; Associate Professors Harrington, M. W. Johnson, Marriott, and Pfeifer; Assistant Professors Cunningham, Hill, L. J. Johnson, Marshall, and Waddington.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

AGRONOMY (AGRO)

411.	Breeding of Field Crops (3)	*Mr. Johnson*
416a.	Soil Characterization and Classification—Lecture (4)	*Mr. Pennock*
416b.	Soil Characterization and Classification—Practicum (1)	*Mr. Pennock*
417.	Forest Soils (3)	*Mr. Pennock*
419.	Soil Properties (4)	*Mr. Baker*
422.	Soil Conservation (3)	*Mr. Cunningham*
423.	Pasture and Grassland Management (3)	*Mr. Washko*
424.	Fertilizer Technology (3)	*Mr. Marriott*
425.	Principles of Field Crop Production (3)	*Mr. Pfeifer*
431.	Soil Fertility and Management (3)	*Mr. Marriott*
438.	Principles of Weed Control (3)	*Mr. Raleigh*
490.	Agronomic Problems (1-6)	*Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Bot. 441. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Phys. 215, Bioch. 425. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Bot. (Zool.) 422. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Bot. (Zool.) 422. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. *Mr. Starling*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and

management practices. Prerequisites: Agro. 28, Bot. 441. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Bot. 441. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 419, G.Sc. 23. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1 per term)

ANIMAL INDUSTRY

Thomas B. King
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professor Bortree; Associate Professor Gobble. Associate Members—Professor King; Assistant Professors Sherritt and Sink.

A student may specialize in animal production and management, animal breeding, or meats. For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
405. Meat Animal Management (4)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Industry Seminar (1)
431. Advanced Meat Selection and Grading (2)

500. Seminar in Animal Industry (1-6)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

*Credits 1-6 per term.

503. Problems in the Animal Industry (1-6) Literature review, research methods, and current research in problems relating to the animal industry.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

ANIMAL NUTRITION

Thomas B. King
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Barron, Bratzler, and Hartsook; Associate Professor Hershberger. Associate Members—Professors Cowan and King; Assistant Professor Long.

The graduate program emphasizes nutrition, including energy metabolism, physiology of nutrition, and growth. For admission without deficiencies an applicant should have had at least one year's work each in general chemistry, organic chemistry, and physics; 3 credits in analytical chemistry; 3 credits in biochemistry; mathematics through integral calculus; and 9 credits in biology.

ANIMAL NUTRITION (A NTR)

401. Physiology of Nutrition (3) *Mr. Hartsook*
402. Energy and Protein Metabolism (3) *Mr. Hartsook*

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY

Donald P. Kent
Head of the Department of Sociology and Anthropology
237 Graduate Hall

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Senior Members—Professors Baker, Carpenter, F. R. Matson, Mook, and Sanders. Associate Member—Assistant Professor Nydegger.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit.
Sociology may be chosen as a minor field by students majoring in anthropology. A thesis is required of all M.A. candidates in this field.

ANTHROPOLOGY (ANTHY)

401. Human Evolution (3)
402. Human Ecology (3)
420. Archaeology of the Near East (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
440. Ethnology of South America (3)
443. Ethnology of the Old World (3-6)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
450. Primitive Society (3)
451. Economic Anthropology (3)
455. Culture and Personality (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Applied Anthropology (3) Methods and results of studies in which anthropological theory was applied to current problems in human biology and culture.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

530. Individual Study in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-6) Individual field work in any aspect of anthropology, supervised by staff of professorial rank.

562. Laboratory Methods in Anthropology (3-6) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

ARCHITECTURAL ENGINEERING

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty: Senior Member—Professor Richardson. Associate Members—Associate Professor Albright; Assistant Professor Knott.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirements for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)
430. Architectural Engineering (3)
431. Architectural Engineering (3)
432. Architectural Engineering (4)
433. Architectural Engineering Thesis (2)
434. Architectural Engineering Thesis (2)
435. Architectural Engineering Thesis (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)
464. Advanced Architectural Illumination Systems Design (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.
Mr. Richardson and Staff

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar. *Mr. Richardson and Staff*

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE

GREGORY AIN, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.
Graduate Faculty: Senior Member—Professor Ain. Associate Member—Professor Hallock.

For admission, a degree of Bachelor of Architecture, Bachelor of Science in Architecture, or Bachelor of Fine Arts in a five-year curriculum in architecture is required.

ARCHITECTURE (ARCH)

415. CITY PLANNING (3)
416. CITY PLANNING (3)
443. ARCHITECTURAL DESIGN ANALYSIS (3)

501. ARCHITECTURAL DESIGN (4-8) Problems in advanced planning and design, including study of group composition. Practicum and seminar.

502. ARCHITECTURAL RESEARCH (2-12) Prosecution of assigned problems under the guidance of an instructor.

ART

WIRTH V. MCCOY, *Head of the Department*
210 Arts Building

Degrees Conferred: M.A., M.F.A.
Graduate Faculty: Senior Member—Professor Heller. Associate Members—Professors McCoy and Zoretich; Associate Professors Altman, Cook, Fraenkel, Montenegro, and Shobaken.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

ART (ART)

411. SEMINAR IN ART (3)
*425. ADVANCED DRAWING (3)

*May be repeated for a total of 12 credits.

*430. Advanced Sculpture (3)
*448. Advanced Printmaking (3)
*450. Advanced Painting (3)
460. Advanced Watercolor (3)
470. Graphic Design II (3)
471. Graphic Design III (3)
472. Exhibition Concepts and Structure (3)
473. Seminar in Design Research (3)
480. Advanced Ceramics (3)
495. Advanced Photography (3)

501. Art Research (2-6) Original study and practice in art relating to material, concept, or technique.

530. Advanced Sculpture (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. Printmaking (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. Painting (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. Design (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

580. Ceramics (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

ART EDUCATION

Edward L. Mattil, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Beittel and Mattil; Associate Professor Edmonston. Associate Members—Associate Professors Chomicky and Schwartz; Assistant Professor Frankston.

Graduate programs in this field prepare students for careers in public school art teaching, art supervision, college teaching, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree.

ART EDUCATION (A ED)

404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)

*May be repeated for a total of 12 credits.

420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Methods in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

534. Creative Art Activity for the Handicapped (3) Specific methods for development of creative art activity with the physically, mentally, emotionally, and socially handicapped; adjustive effect upon them. Prerequisite: 6 credits in art education or 6 in special education or 6 in psychology.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

598. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

599. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 level, including A.Ed. 598.

ART HISTORY

Winston R. Weisman, *Head of the Department*
229 Arts Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Battisti, Enggass, Hyslop, and Weisman. Associate Member—Assistant Professor Mauner.

Graduate work is offered in the following areas: Modern, Renaissance and Baroque, Medieval, Ancient. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

For admission a minimum of 18 credits in art history is required. Lacking these, a promising candidate may be accepted on condition that he make up the deficiency without graduate degree credit. Candidates for the M.A. are required to complete a master's thesis and to demonstrate a reading knowledge of at least one foreign language. Candidates for the Ph.D., upon completion of course work and before beginning the thesis, must pass a written comprehensive examination. They must also demonstrate a reading knowledge of two foreign languages, one of which is to be French or German.

ART HISTORY (ART H)

100. Studies in Art History (3-6 per term)
101. Studies in Greek Art (3)
102. The Illuminated Manuscript (3)
105. Pioneers of Modern Architecture (3-6)
110. Taste and Criticism in Art (3)
111. Art of Imperial Rome (3)
112. The Gothic Cathedral (3)
114. Studies in Italian Baroque Art (3-9)
115. The Skyscraper (3)
116. American Painting: 1876-1913 (3)
122. Studies in Medieval Sculpture (3)
123. Studies in Italian Renaissance Art (3-9)
124. Masters of Northern Baroque Art (3)
125. Movements in 19th Century Art (3)
135. Movements in 20th Century Art (3-6)

510. Art History Research (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. Seminar in Ancient Art (3-12) Selected topics from the history of Greek and Roman art. Prerequisites: Art H. 100 or 110, plus 3 additional credits in art history.

512. Seminar in Medieval Art (3-12) Original research into problems dealing with the art of the Middle Ages.

513. Seminar in Renaissance Art (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. Seminar in Baroque Art (3-12) Investigations in the area of Baroque art centering around major masters and monuments.

515. Seminar in Modern Art (3-12) Lectures, readings, reports, and discussions in the field of modern art.

525. Seminar in Modern Architecture (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

ASTRONOMY

JOHN P. HAGEN, *Head of the Department*
330 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professor Hagen; Associate Professor Sampson Associate Members—Associate Professor Bauer; Assistant Professor Winkler.

Opportunities are available to prepare for research or teaching. The principal research facilities of the department are in radio astronomy, but work can be done in meteors, astrophysics, and in various phases of theoretical astronomy. Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy.

A bachelor's degree in astronomy, physics, mathematics, or related branches of engineering is required for admission. Opportunity to make up possible undergraduate deficiencies is provided.

ASTRONOMY (ASTRO)

430. GENERAL ASTRONOMY FOR TEACHERS (3)
470. SOLAR PHYSICS (3)
490-491. INTRODUCTION TO ASTROPHYSICS (3 each)
495. PRACTICAL ASTRONOMY (3)

510. ASTROPHYSICS (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. ASTROPHYSICS (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. ASTROPHYSICS (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussions of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

520. GALACTIC STRUCTURE (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

522. SPHERICAL ASTRONOMY (3) Astronomical coordinate systems, Kepler's equation, aberration, parallax, precession and nutation, time, eclipses and occultations, and solar motion.

525. DOUBLE STARS (3) Two-body theory; analysis of visual, astrometric, spectroscopic, and eclipsing binaries; and discussions of particular systems. Prerequisite: Astro. 522.

582. RADIO ASTRONOMY (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. RADIO ASTRONOMY (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

590. SPECIAL TOPICS (1-3 per term) Theoretical studies in any field of modern astronomy or astrophysics, with or without associated experimental work. Prerequisites: Astro. 510, 511, 512.

BIOCHEMISTRY

JOHN H. PAZUR, *Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Clagett, Mallette, Pazur, Pritham, and Sullivan; Associate Professor Shigley; Assistant Professor R. Schraer. Associate Members—Assistant Professors Loerch, McCarl, Mumma, and Steinman.

Opportunities for research and graduate study are available in plant metabolism and photosynthesis, intermediary metabolism, nucleic acids, proteins, carbohydrates, lipides, enzymes, vitamins and nutrition, clinical chemistry, endocrinology, and pesticides.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission.

BIOCHEMISTRY (BIOCH)

401. GENERAL BIOCHEMISTRY (4) *Mr. Clagett*
402. GENERAL BIOCHEMISTRY (4) *Mr. Clagett*
404. FOOD CHEMISTRY (3-4)
417. BIOCHEMICAL METHODS OF ANALYSIS (4) *Mr. Loerch*
425. BIOPHYSICAL CHEMISTRY (4) *Mr. Mumma*
426. BIOCOLLOIDS (3) *Mr. Mallette*
436. PHYSIOLOGICAL CHEMISTRY (3) *Mr. Pritham*
437. PHYSIOLOGICAL CHEMISTRY (3) *Mr. Pritham*
438. CLINICAL METHODS (3) *Mr. Pritham*
439. PROBLEMS IN BIOCHEMISTRY (1-12)

501. ENZYMES (2) Investigations and theories concerning nature of enzymes, enzyme action, influence of chemical environment on enzyme action, and biological applications. Prerequisite: Bioch. 402 or 437. Fall term. *Mr. Clagett*

503. BIOCHEMICAL PROBLEMS (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor.

505. VITAMINS AND DIETARY DEFICIENCY DISEASES (2) Lectures, conferences, and assigned reading. Prerequisite: Bioch. 402 or 437. Fall term, odd years.

507. SEMINAR IN BIOCHEMISTRY (1 per term)

510. PROTEINS, AMINO ACIDS, AND PEPTIDES (2) Organic, physical, and biological chemistry of the naturally occurring compounds of this group. Prerequisites: Bioch. 425; 402 or 437. Fall term. *Mr. Mallette*

511. CARBOHYDRATES (2) Chemical constitution and properties of carbohydrates; their metabolism in plant and animal organisms. Prerequisite: Bioch. 402 or 437. Spring term. ***Mr. Mumma***

512. LIPIDES (2) Investigations on biochemistry of fats and related substances. Winter term. *Mr. Shigley*

516. Chemistry of the Pesticides (2) Lectures and assigned readings on the chemistry of insecticides, fungicides, herbicides, rodenticides, and related materials. Prerequisites: Chem. 31; Bioch. 402 or 437. Winter term, even years.

517. Endocrine Secretions (2) Chemistry of hormones and their physiological significance. Prerequisite: Bioch. 402 or 437. Spring term, even years. *Mr. Pritham*

519. Intermediary Metabolism (3) Processes involved in the utilization of metabolites in plants and animals. Prerequisite: Bioch. 402. Spring term. *Mr. Mallette*

520. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on proteins and enzymes. Prerequisite or concurrent: Bioch. 501, 510. Fall term. *Messrs. Clagett and Mallette*

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipides and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512. Winter term.
Messrs. Shigley and Mumma

530. Special Topics in Biochemistry (2-4)

BIOLOGICAL SCIENCE

Leon R. Kneebone, *Chairman of the Committee on Biological Science*
117 Buckhout Laboratory

Degrees Conferred: D.Ed., M.Ed.
Graduate Faculty: Senior Members—Professors Cooper, Davis, Grun, Hale, Kneebone, Schein, and J. E. Wright; Associate Professors Bellis and Kovar. Associate Members—Associate Professors Hillson and Wood.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including at least one year of chemistry. In addition, 18 credits in education and related psychology are required for admission to the M.Ed. program. As many as 6 credits may be made up as undergraduate deficiencies after the candidate is admitted to the Graduate School.

The candidate for the M.Ed. degree must earn at least 24 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in educational foundations and a term paper are required.

The D.Ed. program, designed for secondary school and college science teachers, requires a minimum of 60 credits in natural science of which at least 45 must be in biological science. A minimum of 15 credits each is required in professional education and in thesis research. In addition, a reading knowledge of one foreign language is required.

BIOPHYSICS

Ernest C. Pollard, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professor Pollard; Associate Professors Deering, Ginoza, H. Schraer, Smythe, and Strother; Assistant Professor Snipes. Associate Members—Associate Professor Person; Assistant Professor Taylor.

This program is designed for those interested in applying physical methods to the problems of living systems. A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. Opportunity to make up possible undergraduate deficiencies is provided in the program.

Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by the faculty. These include courses in physics, chemistry, biochemistry, zoology, botany, and microbiology.

BIOPHYSICS (BPHYS)

410. Special Topics (1-6)
473-474-475. Biophysics (2 each)

580. Biophysical Science (3) Theory of muscular contraction, heart action, and nerve conduction; X-ray analysis of proteins and nucleic acids; enzyme kinetics and thermodynamics.

581. Radiation Biophysics (2) The action of ultraviolet and ionizing radiation and of radioactive decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 474.

582. Biophysics of Nucleic Acids (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

583. Special Topics in Biophysics (1-6 per term)

584. Seminar in Biophysics (1-3 per term)

585. Electron Microscopy in Biological Science (3) Principles of electron microscopy and application of techniques for the study of the ultrastructure of biological materials. Prerequisite: any of the following—Bphys. 473, Zool. 437, Bot. 405, Micrb. 401.

BOTANY

Joseph G. O'Mara, *Head of the Department*
206 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Fergus, Grove, Grun, Kneebone, O'Mara, and Wright; Associate Professors Kovar and Schein; Assistant Professor Hamilton. Associate Members—Associate Professor Hillson; Assistant Professor Pursell.

Programs are offered in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics.

See also "Plant Pathology" and "Genetics."

BOTANY (BOT)

400.	Comparative Plant Morphology (4)	*Mr. Hillson*
403.	Plant Biology for Teachers (3)	*Mr. Westerfeld*
404.	Plant Biology for Teachers (3)	*Mr. Westerfeld*
405.	(Zool. 405) General Cytology (3)	*Mr. Grun*
407.	Plant Anatomy (3)	*Mr. Hillson*
414.	Taxonomy of Vascular Plants (3)	*Mr. Keener*
419.	Mycology (3)	*Mr. Fergus*
421.	Botanical Technique (3)	*Mr. Pursell*
422.	(Zool. 422) Advanced Genetics (3)	*Messrs. Wright and Grun*
441.	Plant Physiology (3)	
442.	Plant Physiology (3)	
443.	Plant Physiology (3)	
450.	Plant Autecology (3)	*Mr. Wagner*
451.	Plant Synecology (3)	*Mr. Kovar*

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Spring term. *Mr. Hamilton*

501. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years. *Mr. Fergus*

505. (Zool. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Bot. 405 or 422. Spring term, odd years. *Mr. Grun*

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Bot. 407. Spring term, even years. *Mr. Hillson*

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration, and catabolism. Prerequisite: Bot. 442. Fall term. *Mr. Hamilton*

512. Advanced Plant Physiology (3) Continuation of Bot. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Bot. 442. Winter term. *Mr. Hamilton*

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years. *Mr. Kovar*

518. Special Problems (1-12) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment

521. Medical and Industrial Mycology (3) Structure, life histories, classification, and techniques of study of the fungi pathogenic to man and of fungi important in industry. Fall term, odd years. *Mr. Fergus*

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Bot. 419. Winter term, even years. *Mr. Fergus*

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Bot. 419. Spring term, even years. *Mr. Fergus*

524. (Zool. 524) Seminar in Genetics (1 per term) *Messrs. Wright and Grun*

528. (Zool. 528) Population Genetics (3) Factors affecting gene frequency, genotype frequency, genotype-environmental interaction, and genetic relationship in natural and artificial populations. Winter term, even years.

533. (Zool. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years. *Mr. Grove*

537. (Sec.Ed. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

538. Botany Seminar (1 per term) Presentation and discussion of selected topics.

539. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years. *Mr. Pursell*

540. Algology (4) Comparative morphology, taxonomy, and ecology of fresh water and marine algae; culturing, collection, preservation techniques. Prerequisite: Bot. 421. Spring term, odd years. *Mr. Hillson*

BUSINESS ADMINISTRATION

William L. Ferrara
In Charge of Graduate Programs in Business Administration
122 Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.
Graduate Faculty: Senior Members—Professors Beranek, Bradley, Carzo, Cook, Ferrara, Greenlaw, Kelley, Kniffin, McKinley, Pashek, Richards, Rigby, Saylor, Schrader, Strong, Waters, and Wherry; Associate Professors Babione, Coyle, Gotterer, and Philips. Associate Members—Professor G. K. Nelson; Associate Professors Beik, Carroll, Clewett, Hammond, Phalan, Shilling, and Williams; Assistant Professors Bennett, Cramer, Frey, Hottenstein, Millman, Willingham, and Yanouzas.

The M.B.A. program is designed for those desiring professional education in business administration in preparation for a career in either business or teaching, regardless of their undergraduate backgrounds. An applicant with little or no training in business administration may be admitted to the M.B.A. program and may schedule necessary preparatory courses while pursuing the graduate program. Three credits are required as preparatory courses in each of the following: accounting, business law, business statistics, economics, finance, management, and marketing.

The M.S. and Ph.D. degrees with a major in business administration are designed for those interested primarily in research and teaching. For admission to these programs, a minimum of 18 acceptable undergraduate credits in the fields of accounting, commerce, economics, and business statistics—including at least 6 in economics and 3 in business statistics—is required. An applicant may be admitted with slight specific deficiencies which must be made up without degree credit. Students completing master's degree programs in business administration must complete, either as an undergraduate or as a graduate student, the equivalent of basic instruction in the

fields of economics, accounting, statistics, business law or legal environment of business, business finance, marketing, and management.

Applicants for the various graduate programs in business administration are required to take the Admission Test for Graduate Study in Business given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. The test is given at University Park and at numerous locations in most states and foreign countries in November, February, April, and July. For dates and locations see the *Bulletin of Information*, Admission Test for Graduate Study in Business, published by the Educational Testing Service, Princeton, New Jersey. Applicants should read the bulletin carefully. All arrangements for taking the test must be made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Auditing Concepts and Techniques (3)
404. Managerial Accounting (3)
406. Advanced Federal Tax Accounting (3)
409. Machine and Electronic Accounting Methods (3)

*398G. Accelerated Elementary Accounting (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to graduate students only.

500. Accounting Seminar (3-6)

503. Seminar in Auditing (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.

504. Seminar in Managerial Accounting (3-6) Accounting and the managerial processes of planning, control, and decision-making.

507. Seminar in Financial Accounting (3) Theoretical basis of financial accounting.

508. Contemporary Issues in Accounting (3) Selected problems of current interest to the accounting profession.

511. Interpretation of Account Data (3)

515. Development of Accounting Thought (3) Development of accounting thought from ancient civilizations to the present.

520. Problems in Accounting (3-6) Planned individual projects involving library, laboratory, or field work.

BUSINESS ADMINISTRATION (B A)

462. Problems in Trade and Transportation (3)

503. Seminar in Public Utilities (3)

*No graduate credit is given for this course.

517. International Business Practices (3) Practices of exporters and importers dealing in commodities traded in world markets under competition, monopoly, or governmental control. Prerequisite: B.A. 162.

540. Business Administration Theory and Practice (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

552. Business Research Methods (3) Research methods applicable to business problems with emphasis on means of obtaining data and the logic underlying research design.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to overall company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administation.

BUSINESS LOGISTICS (B LOG)

410. Transportation and Public Policy (3)
412. Transportation Decision Techniques (3)

504. Problems in Business Logistics (3-6) Planned individual projects involving library, laboratory, or field work.

538. Transportation and Physical Distribution (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

565. Seminar in Business Logistics (3-6)

BUSINESS STATISTICS (B S)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)
451. Analytical Methods in Business (3)
452. Analytical Methods in Business (3)
461. Probabilistic Models in Business (3)
490. Special Topics (3-6)

*398G. Accelerated Business Statistics (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

FINANCE (FIN)

406. Investment Valuation and Management (3)
408. Credit Institutions (3)

* No graduate credit is given for this course.

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision-making.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. Estate Planning (3)

500. Insurance Theory and Practice (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

504. Problems in Insurance (3) Planned individual projects involving library, laboratory, or field work.

510. Risk Management (3) Analysis of managerial problems and responsibility for risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

MANAGEMENT (MGMT)

430. Administrative Management (3)
432. Simulation of Management Systems (3)
435. Cases in Public Relations (3)

510. Operations Management (3) Integration and application of decision-making to operational and policy problems within the business firm.

520. Organization Theory (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

522. Personnel Management (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

530. Seminar in Management (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

MARKETING (MKTG)

410. International Marketing (3)
423. Sales Management (3)
424. Marketing Research (3)
427. Advanced Retailing (3)

*398G. Accelerated Marketing Management (3) Analyses of customer and market behavior, marketing systems and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

* No graduate credit is given for this course.

504. Problems in Marketing (3-6) Planned individual projects involving library, laboratory, or field work.

523. Seminar in Marketing (3-6) Research in modern marketing trends.

534. Marketing Management (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

BUSINESS EDUCATION

F. Wayne House
In Charge of Graduate Programs in Business Education
243 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Member—Professor House.

This program provides advanced preparation for teachers of business subjects for secondary schools and colleges. The subject-matter areas encompass secretarial, accounting, retailing, clerical, and general business sequences. The program may be adapted for the preparation of supervisors of business education.

A minimum of 18 acceptable undergraduate credits in education and psychology plus a minimum of 30 credits in business and business education subjects are required for admission.

All candidates specializing in business education are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanities.

BUSINESS EDUCATION (BUS ED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

511. Internship in Business Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on

current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CERAMIC SCIENCE

Floyd A. Hummel, *Head of the Department*
219 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Buessem, Hummel, Weyl, and Williamson; Associate Professors Rindone and Stubican. Associate Member—Assistant Professor McKinstry.

The background for admission is a bachelor's degree in ceramics or in one of the related physical sciences. A knowledge of differential and integral calculus is required together with adequate physics and chemistry.

In view of the wide field covered by ceramic science, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass technology. This makes it easily possible for students whose major subject for the bachelor's or master's degree has been either physics or chemistry to take appropriate graduate studies in ceramic science.

Special facilities exist for research in the areas of clay mineralogy, phase equilibria, mineral synthesis, mechanical properties, ferrite and ferroelectric studies, glass technology, and high temperature reaction kinetics.

CERAMIC SCIENCE (CER SC)

400.	(Min. 400) Nonmetallic Crystal Chemistry (2)	*Mr. Brindley*
402.	Principles of Ceramic Engineering (3)	*Mr. Williamson*
404.	Ceramic Seminar (1)	*Mr. Hummel*
405.	Ceramic Research and Design (1)	
406.	Rheology and Fluid Properties of Ceramic Systems (2)	*Mr. Williamson*
407.	Ceramic Materials Laboratory (2)	*Mr. Williamson*
408.	Heat Treatment of Ceramic Materials (1)	*Mr. Stubican*
409.	Heat Treatment Laboratory (2)	*Mr. Stubican*
410.	Phase Relations in Ceramic Systems (3)	*Mr. Hummel*
411.	Principles of Ceramic Processes (2)	*Mr. Buessem*
412.	Surface Chemistry of Ceramic Materials (1)	*Mr. Weyl*
414.	Principles of Ceramic Technology (2-3)	*Mr. Hummel*
415.	Principles of Glass Technology (3-4)	*Mr. Rindone*
420.	Refractories (2-3)	*Mr. Stubican*
425.	Ceramic Research and Design (2)	
430.	Electroceramics (2-3)	*Mr. Buessem*

500. Seminar in Ceramic Science (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science. *Mr. Hummel and Staff*

501. Colloidal Behavior of Clays and Muds (2-4) Surface chemistry of clays; rheology of ceramic powders, suspensions, and pastes. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Science (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Brindley*

506. Mechanical Properties of Ceramic Materials (2-3) Experimental stress-strain-time relations in elasticity, anelasticity, plasticity, and rupture; theory of strength and control. *Mr. Buessem*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Buessem*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. The Constitution of Glass (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Mr. Weyl*

512. Selected Properties of the Vitreous State (2-3 per term) Measurement and interpretation of such properties as: radiation effects; visco-elasticity; electrical, mechanical, optical, and thermal properties. *Mr. Rindone*

515. Special Problems in Ceramic Science (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Science (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Hsu*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in ceramic science studies are listed under Mineral Sciences.*

CHEMICAL ENGINEERING

Merrell R. Fenske, *Head of the Department*
131 Chemical Engineering Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Braun, Fenske, Jones, Klaus, Mc-Cormick, and Quiggle; Associate Professor Hersh. Associate Members—Associate

CHEMICAL ENGINEERING

Professor Snyder; Assistant Professors Daubert, Engel, Evans, and Kabel.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, mass transfer, transport phenomena, unit operations, unit processes, nuclear chemical engineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. The facilities for instruction and research in chemical engineering and petroleum chemistry include those of the Petroleum Refining Laboratory.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit.

Thesis research for the M.S. and Ph.D. degrees in chemistry may be done in the Department of Chemical Engineering.

CHEMICAL ENGINEERING (CH E)

404.	Chemical Plant Design (3)	*Mr. Engel*
405.	Thermodynamics for Chemical Engineers (3)	*Mr. Snyder*
406.	Chemical Engineering Problems (3)	*Messrs. Engel and Snyder*
410.	Chemical Engineering Principles (3)	*Messrs. Daubert and Kabel*
411.	Chemical Engineering Principles (3)	*Messrs. Daubert and Kabel*
412.	Chemical Engineering Principles (3)	*Messrs. Daubert and Kabel*
415.	Analysis and Mathematical Simulation in Chemical Engineering (3)	*Mr. Snyder*
420.	Cryogenic Engineering (3)	*Mr. Fritz*
422.	Petroleum Processes and Products (2)	*Mr. Peiffer*
426.	Introduction to Transport Phenomena (3)	*Mr. Engel*
430.	Nuclear Chemical Engineering (3)	*Mr. Evans*
435.	Chemical Reaction Kinetics (3)	*Mr. Kabel*
440.	Chemical Engineering Materials (3)	*Mr. Engel*
445.	Chemical Engineering Research (1-5)	
450.	Process Dynamics (3)	*Mr. Snyder*
460.	Chemical Engineering (4)	*Mr. Evans*

500. Seminar in Chemical Engineering (1) Required of all graduate students.

505. Special Topics in Chemical Engineering (2-12) Intensive study in the various specialized fields of chemical engineering.

508. Principles of Industrial Organic Chemistry (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452, Ch.E. 30.

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Mass Transfer (3) Problem course on developments in diffusion, fluid dynamics, and phase equilibrium.

524. Chemical Engineering, Application of Thermodynamics (3) Element of thermochemistry and thermodynamics of greatest importance in chemical engineering.

530. Heat Transfer in Nuclear Reactors (3) Fluid flow, heat transfer, an

design problems in nuclear reactor systems.

535. Applied Reaction Kinetics (3) Basic principles of chemical kinetics, simultaneous heat and mass transfer, and prediction of rates; their application to reactor design.

CHEMISTRY

Thomas Wartik, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Aston, Deno, Dixon, Fritz, Hutchison, Jordan, Lampe, Miller, Noll, Oakwood, Quiggle, Seward, Skell, Smith, Wartik, and Zook; Associate Professors Ascah, Bernheim, Haas, Hayes, Hisatsune, Jones, Olofson, Richey, Schempf, Shamma, and Steele. Associate Members—Assistant Professors Adams, Benkovic, Gold, Long, Lotz, Matwiyoff, Morris, and Rosenblatt.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent and the computer, cryogenic, petroleum, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at 1 p.m. at a departmental colloquium.

Students entering programs leading to the M.S. and Ph.D. degrees should have had training which includes at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is required, and a reading knowledge of at least one foreign language, preferably German, is expected.

Prior to scheduling their first term program, new students will take examinations in the four areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. Chemical Literature (1)
401. Seminar (1)
405. Nuclear and Radiochemistry (3)
410. Advanced Inorganic Chemistry (4)
*421-422. Analytical Chemistry (4 each)
426. Chemical Instrumentation (3-5)
435. Organic Preparations and Laboratory Methods (3-5)
437. Qualitative Organic Analysis (3)
439. Advanced Organic Chemistry (3)
448. Colloid Chemistry (3)
*451-452. Physical Chemistry (3 each)
453. Advanced Physical Chemistry (3)
454. Advanced Physical Chemistry (3)

* Graduate credit not allowed for students majoring in chemistry or chemical engineering.

455. Physical Chemistry of High Polymers (3)
*457-458. Experimental Physical Chemistry (1 each)
459. Experimental Physical Chemistry (1)
470. Chemical Microscopy (3)
471. Special Topics in Chemical Microscopy (2-6)
472. Quantitative Organic Microanalysis (3)
477. Chemical Photomicrography (3)
489. Introduction to Chemical Research (1-10)
†490. Organic Chemistry for Teachers (4)
†492. Advanced General Chemistry for Teachers (3)
†493. Selected Topics in Chemistry for Teachers (3-12)
†494. Chemical Demonstrations for Teachers (3)

500. Seminar in Inorganic Chemistry (1 per term)

501. Seminar in Physical Chemistry (1 per term)

502. Seminar in Organic Chemistry (1 per term)

503. Seminar in Analytical Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Separative and determinative processes in analytical chemistry.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12)

534. Theoretical Organic Chemistry (3) Modern theories of structure; resonance; interpretation of physical properties; theory of rates; equilibrium properties *Mr. Aston*

535-536. Organic Chemistry (3 each) Adapted to the needs of those doing research work in organic chemistry.

538. Organic Chemistry (3) Survey of organic chemistry arranged primarily for graduate students majoring in fields other than organic chemistry.

542. Colloids (3) The physics and chemistry of surfaces and their resulting colloid properties; methods of preparing colloids. *Mr. Smith*

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Chemical Thermodynamics and Introductory Statistical Mechanics (3) Continuation of Chem. 544 including the calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisite: Chem. 544.

546. Quantum Chemistry (3) Calculation of electronic properties of atoms and molecules by wave mechanical methods including molecular orbital theory. Prerequisite: Chem. 565.

* Graduate credit not allowed for students majoring in chemistry or chemical engineering.
† Candidates for the M.Ed. degree.

47. Statistical Mechanics (3) Properties of matter at equilibrium, developed on the basis of energy levels of molecules and statistical mechanical theory. Prerequisite: Chem. 565.

60. Topics in Physical Chemistry (3-12)

61. Chemical Principles (3) Mathematical treatment of the classical principles of chemistry; their application to problems. Required of all graduate students. Prerequisites: Chem. 452, Math. 44, Phys. 204. A course in organic chemistry is recommended.

63. Chemical Kinetics (3) Theory and measurement of the rates of chemical reactions; the mechanism of chemical reactions.

64. Chemical Kinetics (3) Continuation of Chem. 563 including theory and measurement of photochemical reactions.

65. Atomic and Molecular Structure (3) Introduction to modern theoretical chemistry: chemical bonds and molecular spectra.

67. Advanced Theoretical Chemistry (3) Modern and current theories of the properties of chemical substances and their applications to chemical problems; the construction of chemical theory.

81. Experimental Methods in Petroleum Chemistry (1-12)

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS

Joseph H. Britton, *Head of the Department*
S—105E Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Britton, Harms, Morgan, and Smith; Associate Professors Broderick and de Lissovoy. Associate Member—Associate Professor Gravatt.

Programs are concerned with growth, development, and aging and with interpersonal processes in the family and the community. The department includes faculty in both the psychological and social sciences who are particularly committed to these interdisciplinary fields. The perspective encompasses the human life span and the individual's roles in marriage, parenthood, and other social institutions in various cultural settings.

Students are expected to emphasize one area of professional orientation. They may prepare for positions in teaching and research in colleges, secondary and elementary schools, and in nursery schools; for work as human development specialists with children, parents, or other adults; and for service in community agencies.

The department operates preschool and infant laboratories as part of the teaching and research program. Each unit has observational facilities, and there are adjoining rooms for study of individual and group behavior of children and of adults. Additional resources, such as the Psychology Clinic, the Special Education Center for Children, the Speech and Hearing Clinic, and the Computation Center, are available in other parts of the University.

The entering student should have at least 6 credits in the biological and physical sciences, 12 in the social sciences (including a basic course in both sociology and psychology), and 6 in human development and family relationships. Students not

meeting these requirements may be admitted with limited deficiencies to be made u concurrently with their graduate studies.

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CD FR)

415. Child Development and Family Relationships for Secondary Schools (3
418. Family Relationships (3)
429. Advanced Child Development (3)
430. Teaching in Nursery School (1-6)
441. Nursery School Organization (3)
445. (Psy. 445) Development Throughout Adulthood (3)
481. Educational Methods with Preschool Children (3)

500. Nonthesis Research (1-6)

508. Parental Education (3) Discussion and use of methods, experiences, an programs which can be used effectively to help parents in dealing with problem of parent-child relationships.

515. The Teaching of Child Development and Family Relationships (3 Methods of selection and presentation of subject matter basic to understanding th development of children.

529. (Psy. 529) Seminar in Child Development (1-6) Readings and repor on recent findings in child development. Prerequisites: 6 graduate credits in chil development, child psychology, or educational psychology, plus 3 in statistics.

530. Problems in Child Development and Family Relationships (1-6) Prob lems involving individual research in library, laboratory, or field projects.

536. (Psy. 536) Research Methods in Child Development (3) Prerequisites 6 credits in child development and a course in statistics.

545. The Family in Its Community (3) Cultural influences on family relation ships; how the family orients its members to community living and group partic pation.

546. Seminar in Family Relationships (1-6) Reading, reports, and discussio of recent research in relationship aspects of family living; particular attention t studies of roles, crises, and adjustments within the family setting.

548. Survey of Research on Sexual Behavior (3) Survey and evaluation o the contributions to the studies of sex by H. Ellis, Freud, Malinowski, Terma Kinsey, and others. Prerequisites: 12 credits at the 400 and 500 level in chil development and family relationships, psychology, sociology, or anthropology; credits in statistics.

549. (Psy. 549) Theories of Child Development (2-3) Historical backgroun of the major theories concerning child development and behavior and their appl cation.

CIVIL ENGINEERING

Benjamin A. Whisler, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members—Professors Brielmaier, Gotolski, Kountz, Nesitt, Perez, Shulits, and Whisler; Associate Professors Blue and Larson. Associate Members—Professor Underwood; Associate Professor Barnoff; Assistant Professor McDonnell.

The entering student should be a graduate in civil engineering from an accredited college of engineering. Students may specialize in structures, hydraulics, transportation engineering, surveying, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

See also "Sanitary Engineering."

CIVIL ENGINEERING (C E)

200. Seminar (1-3)
201. Civil Engineering Projects (2-12)
221. Highways and Streets (3)
223. Highway Safety and Traffic Control (3)
224. Civil Engineering Materials (3)
231. Civil Engineering Construction (3)
244. Engineering Soil Characteristics (3)
245. Soil Exploration and Analysis (3)
246. Advanced Soil Mechanics (3)
247. Advanced Structural Analysis (3)
248. Advanced Structural Design (3)
262. Open Channel Hydraulics (3)
265. River and Waterways Engineering (3)
271. Environmental Sanitation (3)
272. Water Pollution Control (3)

200. Seminar in Civil Engineering (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

201. Civil Engineering Projects (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

221. Transport Planning and Design (2-6) Planning and design of transportation facilities; basic principles and engineering techniques applied to airways, highways, pipe lines, railways, waterways.

224. Advanced Problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

240. Advanced Structural Analysis (2-4) Geometry of flexure; continuous beams, frames, arches; elastic foundations, elastic supports; beams curved in plan; grids; folded plates; domes. Prerequisite: C.E. 46.

241. Advanced Structural Analysis (2-4) Redundant, continuous, hybrid trusses; influence lines; secondary stresses; framed arches; suspension systems; selection of bridge type; space framing. Prerequisite: C.E. 46.

242. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

244. Advanced Structural Design (2-4) Concrete working stress, ultimate strength, limit design; test behavior of beams, slabs, columns; simple and continuous prestressed concrete members. Prerequisite: C.E. 42.

545. Advanced Structural Design (2-4) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 41.

547. Advanced Structural Theory (3-6) Prestressed concrete, arches, suspension bridges, concrete dams, thin shells, and other current topics. Prerequisite: C.E. 447.

550. Engineering Construction (2-4) Construction methods applied to foundations, buildings, bridges, and other civil engineering construction work. Prerequisites: C.E. 41, 42.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fluids (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Advanced Problems in Sanitary Engineering (3-10) Investigations, analyses, and reports on current topics in sanitary engineering.

574. Analytical Evaluations in Sanitary Engineering (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Sewage Treatment Plant Design (1-6) Design of works for treatment of sewage or industrial wastes. Prerequisite: C.E. 71.

578. Industrial Hygiene (3) Principles of control of industrial toxics and the protection of the worker and the community.

CLOTHING AND TEXTILES

Ruth W. Ayres, *Head of the Department*
S—120A Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professor Ayres; Associate Professor Tesi. Associate Member—Associate Professor Densmore.

Work may be taken with major emphasis in the textile area, which stresses the background natural sciences, or in the clothing area, which stresses the background social sciences. Candidates are accepted who have a strong foundation and a good record in any of the following: home economics, chemistry, sociology, economics, or psychology.

CLOTHING AND TEXTILES (CL TX)

400. Special Problems in Clothing and Textiles (1-6)
402. Fundamental Principles of Tailoring Construction (3) *Mrs. Larson*
403. Creative Pattern Making (3) *Mrs. Larson*
404. Draping (3) *Mrs. Larson*
406. Fashion Promotion (3) *Mr. Tesi*
407. The Textile and Clothing Industry (3) *Mr. Tesi*
408. Intermediate Textiles (3) *Miss Densmore*
410. Clothing for the Family (3) *Mrs. Adams*
411. Advanced Clothing Construction (3) *Mrs. Larson*

500. Nonthesis Research (1-6)

501. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

506. Clothing Behavior (3) Analysis and interpretation of clothing behavior through the application of theories selected from the behavioral sciences.

507. Problems in Relation to Clothing Consumption (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries. *Mr. Tesi*

508. Special Problems in Clothing and Textiles (1-6) Individual directed study, investigation, and practice in selected phases of textiles and clothing.

509. Seminar in Clothing and Textiles (1-6)

510. Research Methods and Evaluation in Clothing and Textiles (1-6) *Miss Densmore*

511. Current Developments in Clothing and Textiles (1-6) *Miss Ayres*

512. History of Clothing and Clothing Construction (3)

513. Advanced Textile Technology (6) *Miss Densmore*

COMPARATIVE LITERATURE

Philip A. Shelley
Chairman of the Committee on Comparative Literature
204 Schwab Auditorium

Degrees Conferred: Ph.D., M.A.

Programs are arranged through a meaningful selection of courses offered by the several departments of languages and literatures, both ancient and modern, as well as of those specifically in the category of comparative literature. Subjects appropriate to such programs of study in international literary and cultural relations include the currency, reception, and influence of writers and works in countries other than those of their origin; the origin, transmission, and evolution of international literary movements; the characteristics and relations of universal literary types, themes, and motifs; literary intermediaries; literary criticism; folk literature and folklore.

In addition to the general requirements for the several degrees the following specific ones are in force:

Master of Arts: Three courses each in two national literatures and two in comparative literature; also a thesis in comparative literature. Language requirements: a thorough reading knowledge of one foreign language in case English is that of one of the literatures selected; otherwise a thorough reading knowledge of both languages of the two foreign literatures comprising the program of study.

Doctor of Philosophy: Beyond the work represented by the attainment of the master's degree in comparative literature or its equivalent, additional courses distributed approximately equal in number among three or four national literatures, including those presented for the master's degree. Additional work in courses specifically labeled comparative literature and a dissertation treating a subject in this field are required. Language requirements: a working knowledge of three foreign languages approved by the candidate's doctoral committee and aural competence in one modern language in addition to English.

COMPARATIVE LITERATURE (C LIT)

443. (Ger. 443) Literary Relations of Germany with England and America (3-9) *Mr. Shelley*

470. Old Masters of the Modern Novel (3) *Mr. Morse*

480. Introduction to Folklore (3) *Mr. Bayard*

500. Seminar in Comparative Literature (3-6)

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to backgrounds, development, themes, and characteristics. *Mr. Bayard*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. Morse*

COMPUTER SCIENCE

Preston C. Hammer, *Head of the Department*
426 McAllister Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Hammer and Selfridge; Associate Professor Laird. Associate Members—Associate Professor McCammon; Assistant Professors Barnes and Wegner.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including foundations of computer science, languages and programming systems, numerical analysis, nonnumeric procedures, and heuristic

methods. The Computation Center has modern digital equipment and systems available for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent of Cmp.Sc. 401 and at least three of the five following: (1) Math. 441 or 481, (2) Cmp.Sc. 410, (3) Math. 453, (4) Math. 454, (5) Math. 428 or E.E. 471. The remainder of these five must be completed for the M.S. or Ph.D.

The M.S. candidate must satisfactorily complete (a) Cmp.Sc. 510 or 511 and (b) Cmp.Sc. 530 or 540, in addition to the other requirements of the Graduate School.

Admission as a candidate for the Ph.D. normally requires completion of course requirements for the M.S. and a background equivalent to an undergraduate major in mathematics.

The Ph.D. candidate must pass three written examinations: one in a field of specialization, one in a field of mathematics, and the third in a related field approved by the doctoral committee.

COMPUTER SCIENCE (CMP SC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Social and Biological Science Applications (3)
403. Principles of Programming with Business Applications (3)
410. Introduction to Computer Systems (3)
453. (Math. 453) Numerical Computations (3)
454. (Math. 454) Matrix Computations (3)
490. Special Topics in Computer Science (1-9)

500. Theory of Automata (3) Foundations of computer science with emphasis on computability; logic and structure of finite automata. Prerequisites: Cmp.Sc. 401, 402, or 403; 3 credits in logic at the 400 level.

501. Algebraic Theory of Automata (3) Prerequisite: Cmp.Sc. 500.

510. Structure of Artificial Languages (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguistics. Prerequisites: 3 credits in logic or logical design at the 400 level; Cmp.Sc. 401, 402, or 403.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multi-access systems, multiprogramming, multiprocessing. Prerequisite: Cmp.Sc. 410.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 401, 402, or 403.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 401, 402, or 403.

590. Seminar in Computer Science (1-3) Topics from current research.

591. Special Topics in Computer Science (2-6)

592. Special Topics in Foundations (2-6)

593. Special Topics in Languages and Systems (2-6)

594. Special Topics in Nonnumerical and Self-improving Systems (2-6)

COUNSELOR EDUCATION

GEORGE R. HUDSON
In Charge of Graduate Programs in Counselor Education
110 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Hudson and Wellington; Associate Professor Hylbert. Associate Member—Associate Professor Kelz.

Professional preparation programs are offered at the master's level for school counselors (elementary or secondary), college student personnel workers, and rehabilitation counselors. Doctoral programs prepare for pupil personnel administration, college student personnel administration, or supervision of rehabilitation.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits in economics, education, psychology, sociology, and physiology or anatomy with some credits in at least three of these areas.

Because school counselors need two years' experience as teachers, social workers, or professional counselors in order to be certified, the experience requirement must be met before receiving a degree. Prospective school counselors lacking such experience should plan to work for their degrees over a series of summers while acquiring requisite experience through the remainder of the year. Those wishing to become college student personnel workers must have a year of appropriate work experience in a college setting before receiving a degree. Prospective rehabilitation counselors are provided with an off-campus supervised internship as part of their professional preparation.

All Counselor Education degrees at Penn State are based, in addition to Graduate School requirements, on demonstrated counselor competencies.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

Courses in counselor education are listed under the offerings of the Department of Educational Services (see page 108). Additional courses are selected from other areas and departments.

DAIRY SCIENCE

DONALD V. JOSEPHSON, *Head of the Department*
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Almquist, Cone, Josephson, Kesler, Patton, and Watrous; Associate Professors Flipse, Keeney, and McCarthy; Assistant Professor Amann. Associate Members—Associate Professor Cloninger; Assistant Professor Thoele.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipide metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, zoology, or agricultural economics.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The

undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

DAIRY SCIENCE (D SC)

405. Dairy Cattle Management (3) *Mr. Cloninger*
418. Dairy Survey (1) *Mr. Josephson*
421. Technical Control Problems (1-10) *Messrs. Watrous and Keeney*
427. Milk Secretion (3) *Mr. Kesler*
428. Dairy Production Problems (1-6)
431. Physiology of Reproduction in Farm Animals (3) *Messrs. Almquist and Amann*

501. Butter and Cheese (1-6) Manufacture and handling of butter and cheese. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Watrous*

502. Condensed Milk and Milk Powder (1-6) Condensing and drying of milk. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Keeney*

503. Public Milk Problems (1-6) Handling milk in modern plants. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Watrous*

504. Ice Cream Manufacture (1-6) Manufacture of ice cream, ices, and other frozen milk products. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Keeney*

505. Dairy Plant Economics (1-6) Economic factors involved in creamery operation and management. Prerequisite: D.Sc. 7. *Mr. Watrous*

507. Dairy Cattle Management (1-6) *Mr. Kesler and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

509. Testing Dairy Products (1-6) Constituents of dairy products. Prerequisites: Bioch. 404, Micrb. 8.

510. Dairy Cattle Feeding (1-6) Application of fundamental research in animal nutrition to the feeding of dairy cattle. Prerequisite: D.Sc. 1. *Mr. Kesler*

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Zool. 422, 3 credits in statistics. *Mr. Thoele*

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Mr. Josephson and Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on

metabolic processes. Prerequisite: Chem. 405. *Mr. Flipse*

522. Research Procedures in Dairy Technology (3) Research problems and methods in dairy technology with major emphasis on dairy chemistry. Prerequisite: Bioch. 404. *Mr. Patton*

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

EARTH SCIENCES

E. Willard Miller
Chairman of the Committee on Earth Sciences
104 Deike Building

Degree Conferred: M.Ed.

This program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, meteorology, and mineralogy.

The program prepares candidates to teach at least one field of the earth sciences, familiarizes them with at least two additional earth science subjects, and at the same time enables them to increase their competence in the physical sciences, the biological sciences, and mathematics.

The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

The following courses offered by the various departments are appropriate for students majoring in earth and space science: Astro. 430; Geog. 490, 491; Geol. 400, 401, 402; Gphys. 400; Meteo. 400, 401, 402, 403, 404; Min. 402.

ECONOMICS

Grant N. Farr, *Head of the Department*
326 Boucke Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Budd, Coppock, Farr, Kaufman, Mares, Mason, Newman, Prybyla, Reede, Roose, Rozen, Saylor, and Stout; Associate Professors Iwand, Klein, Myers, and Robinson. Associate Members—Associate Professors Riew, Sauerlender, and Shearer; Assistant Professor Stromsdorfer.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

The department may waive the requirement of a thesis for M.A. candidates.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics.

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)
404. Current Economic Issues (3)
405. Advanced Economic Analysis (3)
412. Economics of Collective Bargaining (3)
413. Comparative Labor Movements (3)
415. Social Insurance (3)
418. Economics of Wages and Employment (3)
419. Case Studies in Labor-Management Relations (3)
423. State and Local Taxation (3)
429. Advanced Public Finance (3)
433. International Monetary Economics (3)
442. Monopoly, Competition, and Their Regulation (3)
450. The Business Cycle (3)
451. Advanced Money, Banking, and Fiscal Policy (3)
452. The Money Markets (3)
461. Economic Growth: Underdeveloped Areas (3)
462. Economic Growth: Theories of United States Development (3)
475. (L.M.R. 475) Theories of the Labor Movement (3)
480. Mathematical Economics (3)
490. Measurement of the Economy (3)
491. Analysis of Linear Economic Models (3)
499. Foreign Study in Economics (2-6)

500. Economics Seminar (3-6)

506. Problems in Economics (3-6) Planned individual projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity approach to monetary theory; current issues in theory and policy.

510. Econometrics (3) Statistical estimation in mathematically formulated economic relationships.

512. Wage Determination (3) Development of wage and employment theory; structure of labor markets; impact of unions on income distribution, price level, and employment.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

516. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision-making and control.

572. Soviet and Other Centrally Planned Economies (3) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

EDUCATION OF EXCEPTIONAL CHILDREN

WILLIAM R. CARRIKER, *Head of the Department of Special Education*
101 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Bliesmer, Carriker, French, Heilman, McDonald, and Siegenthaler. Associate Members—Associate Professors Berlin and Frick; Assistant Professor Haspiel.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally maladjusted, neurologically impaired, or crippled.

Prerequisites for a master's program include: a valid teaching certificate and 10 credits (2 of which must be in a practicum) in the education of exceptional children.

Applicants for doctoral study shall show evidence of (1) having completed a master's degree with "A" quality grades on at least one third of the graduate courses and (2) attaining a minimum score of 500 on both portions of the Graduate Record Examination, or 50 on the Millers Analogies Test, or 35 on the Quantitative Educational Device.

EDUCATIONAL ADMINISTRATION

WALTER J. DELACY
In Charge of Graduate Programs in Educational Administration
303 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Davison, DeLacy, McAulay, McGarey, Miller, Remaley, and Willower; Associate Professor Bosch.

Professional preparation programs are offered at the master's level for elementary and secondary school principals and supervisors. Doctoral programs prepare for positions of supervising principal, assistant superintendent, and superintendent of schools.

Requirements for admission to a graduate program in educational administration include 18 approved undergraduate credits in education and psychology. Applicants for admission to the master's degree program are required to have had one year of teaching experience, or to be currently engaged in teaching. Two years of teaching experience are required for admission to the doctoral program.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600 or 610 thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term, unless approved by the candidate's committee, shall be considered automatic withdrawal.

Although candidates are required to specialize in a field of professional education, they are also encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

Courses in educational administration (Ed.Ser. 480 and 565 to 582 inclusive) are listed under the offerings of the Department of Educational Services. Additional

courses may be selected from other areas and departments to meet the student's needs, including certification requirements.

DEPARTMENT OF EDUCATIONAL SERVICES—This department (Franklin A. Miller, *Head,* 204 Education and Psychology Center, Building II) offers graduate programs in counselor education, educational administration, and higher education. It also offers the following course sequences which are not graduate majors:

Adult Education	460, 575
History and Philosophy of Education	417-420, 516-523
Research, Seminars, and Projects	596-599
Safety Education	450-452

These courses carry graduate credit and, with the approval of the student's adviser, may be applied toward the requirements for an advanced degree in any major field.

EDUCATIONAL SERVICES (ED SER)

403. Guidance Principles and Practices (3)
404. Teaching and Group Guidance About Occupations (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
420. History of Modern European Education (3)
425. Education of Exceptional Children (2-3)
427. Education of the Mentally Retarded (2-3)
429. Education of the Mentally Gifted Child (1-3)
430. Practicum in the Education of Atypical Children (1-8)
431. Atypical Children and Educational Adjustments (3)
450. Visual and Other Aids in Safety Education (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisites: Ed.Ser. 506, Ed.Psy. 451.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals.

505. Occupational and Educational Information (3) Occupational information for guidance purposes; educational information related to vocational choice and preparation. Prerequisite: Ed.Ser. 403.

506. Student Analysis Procedures for Counselors (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing.

507. Supervised Experience in Student Counseling (3) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Ed.Ser. 403.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Ed.Ser. 403.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Ed.Ser. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Ed.Ser. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisite: Ed.Ser. 511.

513. Supervision of Guidance Workers (3) Practical experience in supervising and evaluating work of counselors. Prerequisite: Ed.Ser. 507.

516. Social Foundations of Education (2-4) Social institutions and functions and their relationship to public education; analysis of the functions assignable to formal education. Prerequisites: El.Ed. 311 or Sec.Ed. 331; Ed.Psy. 14.

517. Advanced Philosophy of Education (2-4) Analysis of educational policy and practice for philosophic consistency and commitment; philosophical implication in selected educational literature.

518. Evolution of Educational Thought (2-3) Rise of formal educational philosophy from Plato to John Dewey; preliminary reference to Chinese, Hindu, Chaldean, Persian, Hebrew, and Egyptian theories.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina.

522. Comparative European Education (3) Educational policies and practices in school systems in western and central European nations. Prerequisite: Ed.Psy. 14.

523. Education in Russia, Asia, and the Middle East (2-3) Current educational activities in Soviet Russia and other eastern European countries; the Middle East, North Africa, and the Far East.

525. Internship in Special Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

527. Problems in the Education of the Mentally Retarded (1-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience; Ed.Ser. 425 or 577, and Ed.Ser. 427.

529. Problems in the Education of the Mentally Gifted (1-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience; Ed.Ser. 425 or 577, and Ed.Ser. 429.

545. Higher Education in the United States (2-3) Historical perspective and current status; development of functions and structures; issues in curriculum, admissions, government, administration, and finance.

546. The Principles of College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in Higher Education (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professional Education of Teachers (3) Development and present status of teacher education; objectives and standards; selection and guidance of students; personnel problems in relation to staff. Prerequisite: 6 credits in advanced courses in education and a course in educational psychology.

551. Student Personnel Programs in Higher Education (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

553. Student Personnel Administration Theory and Research (2-3) Relations of theory, practice, and research on administrative behavior and student personnel services; case study, role playing, programmed decision problems. Prerequisites: Ed.Ser. 551, 555.

555. Seminar in Higher Education (1-6) Special topics in higher education.

565. Principles of School Supervision (2-3) Organization of supervision; planning the supervisory program; developing standards of teaching and learning; improvement of learning through tests and teacher rating. Prerequisites: 18 credits in education and 3 years' teaching experience.

566. The Elementary School Principal as Supervisor (2-3)

567. The Secondary School Principal as Supervisor (2-3) Improvement of instruction; improvement of teachers in service; evaluation of teaching procedures; methods of supervision; selection and use of textbooks. Prerequisite: three years' teaching experience.

568. The Elementary School Principal as Administrator (2-3) Duties of the elementary school principal in organizing and administering his school.

569. The Secondary School Principal as Administrator (2-4) Problems of schedule making, teachers' meetings, curriculum making and revision, organization of extra-curricular and guidance programs. Prerequisite: teaching experience.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration;

taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

574. State and National Education Programs (2-3) Existing state and federal functions and relations to education; proposed programs. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes; torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

577. The Administration of Public School Education for Atypical Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience; Ed.Ser. 573.

580. Seminar in School Administration (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

581. Educational Survey Techniques (2-3) Methods for appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

596. Seminar in Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Education (1-6) Independent work in the study of topics in education or the development of new curriculums,

materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

599. Internship in Public School Research (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

EDUCATIONAL PSYCHOLOGY

William Rabinowitz, *Head of the Department*
311 Education and Psychology Center, Building II

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors DiVesta, French, Mitzel, Rabinowitz, VanOrmer, and Withall; Associate Professors Lathrop, Sparks, and Thevaos; Assistant Professor Seibel; Mr. Greenhill. Associate Members—Assistant Professors Impellitteri, Snyder, and Wodtke.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems, including programmed learning. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Special facilities include a research design laboratory, a laboratory for computer-based instruction, a self-instruction media laboratory, facilities for film production and editing, and a closed-circuit television studio in Chambers Building used for both research and instruction. Facilities in other departments available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with an IBM 7074 Computer, is available for use in graduate student research.

Requirements for admission include a broad undergraduate background including some college mathematics, a minimum junior-senior scholastic average of B, and a satisfactory scholastic aptitude rating on either the Graduate Record Examination or the Miller Analogies Test. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one third of their graduate credits of "A" quality.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in two related areas (one being in this department). Typically, the doctoral program of study would include at least one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, instructional media, measurement, social or industrial psychology, clinical psychology, experimental psychology, and developmental psychology.

EDUCATIONAL PSYCHOLOGY (ED PSY)

400. Statistical Interpretation of Educational Research (2)
406. Applied Parametric and Nonparametric Statistics in Education (3)
407. Regression and Correlation Methods for Educational Data (2)
421. Learning Theories Applied to Educational Practice (3)
450. (Psy. 450) Principles of Measurement (3)

451. Appraisal and Interpretation of Standardized Group Tests (2)
475. Introduction to Educational Research (2)

506. Advanced Techniques for Analyzing Educational Experiments (2) Advanced techniques for research in education; analysis of covariance; repeated measures; randomized block designs; Latin square; and other experimental arrangements. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

520. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 421.

521. Concept-formation, Problem-solving, and Decision-making Processes in Schools (2) Study of paradigms and models of concept formation, problem-solving strategies, choice-making, and judgment as related to complex verbal learning. Prerequisite: Ed.Psy. 520.

530. Theory and Research in Programmed Learning (3) Research and trends in programmed learning; preparation of short programmed sequences for experimental analysis. Prerequisites: Ed.Psy. 450 and 421, or Psy. 404.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

558. Scaling Educational and Psychological Measures (2) Unidimensional and multidimensional scaling models with emphasis on psychometric methods and brief attention to psychophysical methods. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

599. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING

Arthur H. Waynick, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus)

Graduate Faculty: Senior Members—Professors Ferraro, Holt, Lewis, Mentzer, Ross, and Waynick; Associate Professors Hale, Lee, Nisbet, and Quinn. Associate Members—Professor Volz; Associate Professor Marsh; Assistant Professors Adams, Etzweiler, Gothard, Lachs, Laxpati, Seliga, and Steele.

Course offerings and research facilities are available in the following areas: antennas, communications systems, computers (including digital, analog, and network analyzer), control systems, dynamical machine analysis, electron devices, information theory, ionosphere research, microwave theory and techniques, networks, plasmas and MHD, power conversion, power system analysis, servomechanisms, and wave propagation.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate course work in electrical circuits, machinery, and electronics.

ELECTRICAL ENGINEERING (E E)

421a,b,c,d. Electrical Engineering Problems (2-12)
425. Symmetrical Components (3)
426. Transistors (3)
428. Servomechanisms (3)
432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
438. Electromagnetic Theory and Radiating Systems (3)
439. Pulse Techniques (3)
441. Active Circuits (3)
450. Electrical Network Theory (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Digital Computers (3)

514. Quantum and Solid State Electrical Engineering (3) Electron theory of atoms and solid structures, as applied to electrical engineering concepts and devices. Prerequisite: Phys. 412.

520. Seminar (1) Required of all graduate students in electrical engineering. Conferences, reading, and presentation of technical papers.

521. Advanced Electrical Engineering Problems (2-12)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

526. Transistors and Active Circuits (3) Advanced semiconductor electronic theory, transistor circuit analysis, and applications. Prerequisite: E.E. 426.

528. Servomechanisms (3) Advanced treatment of transient and steady-state behavior of closed-cycle control systems with special attention to stability and design of stabilizing controllers. Prerequisite: E.E. 428.

532. Ultra-High-Frequency Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisite: E.E. 432 or 438.

535. Engineering Analysis (3) Engineering applications of complex variables, conformal mapping methods, and potential plotting; Laplace transform methods and stability criteria. Prerequisite: E.E. 435.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electrical and magnetic fields, using the Maxwell-Lorentz equations as applied to vector fields and special solutions for antennae, wave guides, and other engineering applications. Prerequisite: E.E. 438.

550. Passive Network Synthesis (3) Network synthesis using (a) realizability conditions; (b) image parameters, realization methods for two-terminal pair networks; rational fraction approximations; time domain synthesis. Prerequisites: E.E. 450, 535.

560. Information Theory (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; optimum filtering and prediction. Prerequisite: E.E. 45.

561. Information Theory (3) Mathematical measurement of information: information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 560.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 43 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ELEMENTARY EDUCATION

A. Madison Brewer, *Head of the Department*
150 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

ELEMENTARY EDUCATION

Graduate Faculty: Senior Members—Professors Bixby, Brewer, Corle, McAulay, and Russell; Associate Professors Bosch and Zafforoni. Associate Members—Associate Professors Alessandro, Alfke, Coulter, and Riedesell.

The graduate programs provide advanced professional preparation for kindergarten teachers, elementary school teachers, and curriculum specialists. For admission 18 credits in elementary education, including teaching experience, are required.

ELEMENTARY EDUCATION (EL ED)

401. Training in Nature for Camp Counselors (3)
426. Problems of Elementary School Arithmetic (2-3)
433. Teaching Social Studies in the Elementary Grades (2-3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (2-3)
444. Reading Disabilities (2-3)
445. (Sec.Ed. 445) Techniques in Remedial Reading (2-6)
449. Teaching Children's Literature (2-3)
453. Special Problems in the Teaching of Elementary School English (2-3)
461. Elementary Education (2-3)
467. Advanced Theory of Kindergarten (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

526. Applications of Research in the Teaching of Elementary School Mathematics (3) Research applications dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of elementary school mathematics. Prerequisites: El.Ed. 426 and elementary teaching experience; Ed.Psy. 400.

533. Problems and Issues in Elementary School Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: El.Ed. 433 and elementary school teaching experience.

546. (Sec.Ed. 546) Seminar on Reading Instruction (3-6) Research, procedures, and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: El.Ed. 443 or Sec.Ed. 443.

557. Reading Clinic Practice: Remedial Procedures (1-9) Practicum in special classes for reading disabilities; corrective and remedial procedures; specific procedures for correction of various types of reading disabilities. Prerequisite: El.Ed. 444.

559. Reading Clinic Research (1-15) Prerequisites: El.Ed. 443 or Sec.Ed. 443; El.Ed. 444.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principals underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers: administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

594. Seminar in Elementary Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in elementary education.

598. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

ENGINEERING ACOUSTICS

Vernon M. Albers
Chairman of the Committee on Engineering Acoustics
227 Ordnance Research Laboratory

Degrees Conferred: Ph.D., M.S.

The aim of this program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by the several departments of science, engineering, and arts, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Ordnance Research Laboratory.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, or speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Course work should be so distributed that one area is covered in depth while a substantial number of courses are chosen from a combination of the other areas.

ENGINEERING ACOUSTICS (E ACS)

511. Underwater Sound Propagation (4) Theoretical and empirical treatment

of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (4) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Modern Acoustic Signal Processing (4) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

514. Electroacoustic Transducers (4) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.

ENGINEERING MECHANICS

Robert K. Vierck, *Acting Head of the Department*
105 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.
Graduate Faculty: Senior Members—Professors Davids, Hardenbergh, Hu, Vierck, and Wislicenus; Associate Professors Inman, Neubert, and Sharma. Associate Members—Associate Professor Jaunzemis; Assistant Professors Hayek, Kiusalaas, Weitsman, and Zamrik.

Graduate study is available in the following areas: (1) mechanics of rigid bodies including dynamics, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics.

ENGINEERING MECHANICS (E MCH)

400.	Advanced Strength of Materials (3)	*Mr. Kiusalaas*
401.	Elements of Vibrations (3)	*Messrs. Vierck and Hayek*
402.	Applied and Experimental Stress Analysis (3)	
403.	Mechanics of the Solid State (4)	*Mr. Hu*
404.	Research in Engineering Mechanics (1-6)	
407.	Numerical Methods of Analysis (3)	*Mr. Sharma*
408.	Elasticity and Engineering Applications (3)	*Mr. Weitsman*
409.	Advanced Mechanics (3)	*Mr. Hardenbergh*
410.	Mechanics of Space Flight (3)	*Mr. Hardenbergh*
412.	Experimental Methods in Vibrations (3)	*Mr. Neubert*
413.	Plastic Analysis of Structures (3)	*Mr. Hu*
414.	Elements of Material Science (3)	*Mr. Inman*
421.	Continuum Mechanics (3)	*Mr. Jaunzemis*
422.	Continuum Mechanics (3)	*Mr. Jaunzemis*
446.	Mechanics of Viscoelastic Materials (3)	*Mr. Sharma*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick

walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13.

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507.

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13.
Messrs. Hu and Weitsman

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to internal pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics.

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potentials; applications. Prerequisite: E.Mch. 540. *Messrs. Jaunzemis and Weitsman*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 44 or 431. *Messrs. Davids and Jaunzemis*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 44 or 431.
Messrs. Vierck and Neubert

523. Relaxation Methods (3) Relaxation methods compared to iteration and other numerical methods of analysis; application to elasticity, plasticity, stability, fluid flow, heat transfer, and related fields. Prerequisites: E.Mch. 13 or 111, Math. 44. *Messrs. Vierck and Sharma*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: Math. 451 or E.E. 435 or M.E. 452. *Messrs. Davids and Hayek*

Unit A (3) Basic concepts of tensors; matrices; numerical procedures; approximation; Fourier, Legendre, and other orthogonal series; applications; Bessel and other special functions.

Unit B (3) Basic solutions of Laplace, diffusion, wave equations; boundary-value problems; Fourier, Laplace transforms; contour integration techniques; Caignard's energy methods.

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical applications. Prerequisite: E.Mch. 522. *Mr. Neubert*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522 *Mr. Neubert*

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14.
Messrs. Hu and Zamrik

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507.

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Mr. Jaunzemis*

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540 or 421. *Mr. Jaunzemis*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

ENGINEERING SCIENCE

John L. Lumley
Chairman of the Committee on Engineering Science
233 Hammond Building

Degree Conferred: M.Eng.

Programs leading to the degree of Master of Engineering with a major in engineering science are offered only at the King of Prussia Graduate Center and the Capitol Campus Graduate Center at Harrisburg. Details of the programs available may be obtained by writing directly to the dean in charge. Addresses are given on the inside front cover.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area

Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits of course work is required, of which at least 12 must be at the 500 level. A scholarly written report is also required.

A bachelor's degree in engineering or a closely allied field is required for admission.

ENGLISH

HENRY W. SAMS, *Head of the Department*
245 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members—Professors Bayard, Brady, Condee, Cramer, Davis, Euwema, Frank, Goldberg, Lewis, Meserole, Morse, Peck, Rubin, Sams, Sutherland, Weintraub, and Young; Associate Professors Bressler, Jewkes, Oldsey, Reiss, Wellwarth, and West. Associate Members—Associate Professors Austin, Hansen, Reed, and Trachtenberg; Assistant Professors Borklund and Gidez.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work.

A thesis is required of all M.A. candidates in this major.

ENGLISH (ENGL)

406. HISTORY OF THE ENGLISH LANGUAGE (3) *Messrs. Bell, Buckalew, and Shedd*
407. HISTORY OF THE ENGLISH LANGUAGE FOR TEACHERS (3) *Messrs. Bell, Buckalew, and Shedd*
408. ADVANCED COLLEGE GRAMMAR (3) *Miss McElwee*
411. PROBLEMS OF STYLE (3) *Mr. Morse*
412. THE WRITING OF FICTION (3-6) *Messrs. Rubinstein, Rogers, and West*
413. VERSE WRITING (3-6) *Mr. Haag*
414. BIOGRAPHICAL WRITING (3) *Mr. Weintraub*
418. ADVANCED TECHNICAL WRITING AND EDITING (3-6) *Messrs. Hoffman and Houp*
422. MASTERS OF BRITISH LITERATURE (3-6)
423. HISTORY OF BRITISH LITERATURE (3)
424. MOVEMENTS IN BRITISH LITERATURE (3)
432. MASTERS OF AMERICAN LITERATURE (3-6) *Messrs. Bressler, Davis, and Staff*
433. HISTORY OF AMERICAN LITERATURE (3) *Messrs. Sutherland and Gidez*
434. MOVEMENTS IN AMERICAN LITERATURE (3-6) *Messrs. Hansen, Meserole, and Staff*
435. THE AMERICAN SHORT STORY (3) *Mr. Bressler*
437. AMERICAN POETRY (3) *Messrs. Rubin and Hansen*
438. AMERICAN DRAMA (3) *Mr. Wellwarth*
441. POETRY AND PROSE OF THE EARLY 17TH CENTURY (3) *Mr. Condee*

442. Poetry and Prose of the Late 17th Century (3) *Mr. Brady*
443. Jacobean and Caroline Drama (3) *Messrs. Jewkes and Reed*
444. Shakespeare (3) *Messrs. Arnold, Jewkes, and Reed*
445. Chaucer (3) *Messrs. Frank and Reiss*
446. Milton (3) *Mr. Condee*
447. Poetry and Prose of the 16th Century (3) *Mr. Reed*
448. English Drama Before Shakespeare (3) *Mr. Jewkes*
449. Shakespeare (3) *Messrs. Arnold, Jewkes, and Reed*
451. Poetry and Prose of the Early 18th Century (3) *Mr. Sams*
452. Poetry and Prose of the Late 18th Century (3) *Mr. Brady*
455. The Novel in England to Jane Austen (3) *Mr. Brady*
458. The Drama from Dryden to Sheridan (3) *Mr. Rogers*
461. British Prose of the 19th Century (3) *Mr. Cramer and Miss Austin*
462. Wordsworth and Coleridge (3) *Mr. Cramer and Miss Austin*
463. Byron, Shelley, and Keats (3) *Mr. Peck*
465. Victorian Novel (3) *Miss Austin*
466. The American Novel to 1900 (3) *Messrs. Young and Oldsey*
467. Victorian Poetry (3) *Mr. Cramer*
470. Literature of the British Commonwealth (3) *Mr. Sutherland*
475. Modern British Fiction (3) *Messrs. Sutherland and Weintraub*
476. The American Novel Since 1900 (3) *Messrs. Young and Oldsey*
477. British and American Poetry of the 20th Century (3)
478. British and Irish Drama Since 1890 (3) *Mr. Weintraub*
481. History of English Literary Criticism (3) *Messrs. Sams, Bressler, and Borklund*
488. Modern Continental Drama (3) *Messrs. Weintraub and Wellwarth*
490. Rhetorical Theory and Practice (3) *Mr. Bowman*
491. Literature for Teachers in Secondary Schools (3) *Mr. Bressler*
*498. English Institute (6-12)

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Messrs. Meserole and Mann*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. *Mr. Jewkes*

522. Old English Literature (3) A reading of the more important poetic works in Old English. *Mr. Jewkes*

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Mr. Cramer*

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Mr. Cramer*

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Crame*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the 19th and 20th centuries. *Mr. Davi*

*A maximum of 6 credits in one summer.

540. Studies in Elizabethan Prose and Poetry (3-6) *Mr. Reed*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Messrs. Frank and Reiss*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer. *Messrs. Frank and Reiss*

543. Studies in Early 17th Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700. *Mr. Brady*

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Messrs. Frank and Reiss*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Mr. Reed*

552. Swift and Pope (3) *Messrs. Sams and Brady*

553. The Age of Johnson (3) The work of Johnson and his circle. *Mr. Brady*

554. Studies in Early American Literature (3) *Messrs. Meserole and Hansen*

555. The Puritans (3) Critical studies of the principal works of English and American Puritans. *Messrs. Meserole and Hansen*

556. Eighteenth Century British Fiction (3)

557. Early 18th Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. American Romanticism (3) The Romantic movement in American literature of the mid-19th century. *Messrs. Rubin, Davis, and Bressler*

561. Studies in the Romantic Movement (3-6) *Mr. Cramer*

562. Studies in the Literature of Victorian England (3-6) *Mr. Cramer and Miss Austin*

564. Studies in 19th Century American Literature (3) The major figures treated will vary from year to year. *Messrs. Rubin, Davis, and Oldsey*

573. Studies in 20th Century British Literature (3-6) Major writers and literary movements. *Messrs. Morse and Weintraub*

574. Studies in 20th Century American Literature (3-6) Major writers and literary movements. *Messrs. Young and Lewis*

575. James Joyce (3-6) Alternate terms: *Ulysses* and *Finnegans Wake*. Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed. *Mr. Morse*

576. Hemingway and Faulkner (3) The major works. *Mr. Young*

578. Shaw (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. Eliot (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Mr. Lewi*

581. Contemporary Literary Criticism (3) *Messrs. Sams and Brad*

582. Hawthorne and Melville (3) Detailed study of the major works of both authors and of the relationship between the two men. *Mr. Youn*

583. Emerson and Thoreau (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Bressle*

584. Whitman and Dickinson (3) The major texts, with special emphasis on background and language. *Messrs. Rubin and Davi*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature. *Mr. Lewi*

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserol*

590. Research Problems in British Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

591. Research Problems in American Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Youn*

593. Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early 16th century to the present. *Mr. Bayar*

595. Studies in British Fiction (3-6) *Messrs. Sutherland and Weintrau*

596. Studies in American Fiction (3-6) *Messrs. Lewis and Youn*

597. Studies in American Poetry (3-6) *Messrs. Rubin, Davis, and Hanse*

598. Readings in English (1-6) Programs of readings in English and American literature, designed to meet specific needs of individual students.

ENTOMOLOGY

Beckford F. Coon, *Head of the Department*
101 Walker Laboratory

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Senior Members—Professors Asquith, Coon, Frear, and Rutschky; Associate Professors Boyle, Smyth, and Snetsinger. Associate Members—Associate Professors Ercegovich and Yendol; Assistant Professors Benton and Kearby

A student majoring in entomology may specialize in various areas of economic entomology and in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Rutschky*
402. Insect Ecology (3) *Mr. Kearby*
403. (Zool. 403) Systematics (3) *Mr. Boyle*
405. Insect Morphology (3) *Mr. Rutschky*
411. Insect Physiology (3) *Mr. Smyth*
413. Entomology Seminar (1 per term)
429. Insect Control (3) *Mr. Snetsinger*
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

506. Immature Insects (3) The morphology and taxonomy of the immature stages of insects. Spring term, even years.

520. Special Topics (1-6)

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years. *Mr. Smyth*

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications. *Mr. Smyth*

533. Physiology of Nerves, Muscles, and Sense Organs (2-6) Current literature on the function of excitable tissues of insects and other animals. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology. *Mr. Smyth*

535. Biological Control (3) Practical and theoretical aspects of the biological control of arthropod pests. Spring term, even years. *Mr. Yendol*

540. Insect Resistance in Plants (2) Mechanism, expression, permanence, and measurement of resistance to insects with special reference to farm crops. Spring term, odd years. *Mr. Coon*

EXTENSION EDUCATION

Macklin E. John
Chairman of the Committee on Extension Education
1 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competencies which enable them to become more effective professional workers. Options have been developed for the Colleges of Agriculture and Human Development. Additional options will be offered as they are developed by other Colleges.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

FAMILY ECONOMICS AND HOME MANAGEMENT

Marjorie M. Knoll
Head of the Department of Home Management, Housing, and Home Art
S—271 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professor Knoll; Associate Professor Nichols. Associate Members—Professor Hotchkiss; Associate Professor Smith; Assistant Professor Gage.

Those interested in emphasizing a study of home management, family economics, family housing, and home equipment may do so through this major. There are no specific course requirements for admission.

The following courses are available in the area of family housing; their descriptions may be found under the offerings of Home Art: F.H.H.Ar. 401, 440, 441, 470, 515, 530, 541.

In the graduate program family management practices, their effects upon members of the family unit, and the interaction of such practices with the local and national economy are studied in relation to principles of economics, philosophy, psychology, sociology, and political science.

CONSUMER SERVICE AND EQUIPMENT (CS EQ)

403. Lecture-Demonstration Techniques (3)
413. Home Equipment (3)
450. Problems in Household Equipment (1-6)

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

415. Household Buying Practices (3)
419. Managing Family Financial Resources (3)
424. Economic Conditions in Relation to the Family (3)
439. Management Principles in Home Operation (2)
442. Resident Experience in Home Management (3) Room and board will be charged at regular rates. *Miss Chennault*
445. Home Management Experience (3) *Miss Chennault*
477. Family Management (3)

515. Consumer Problems (2-3) Methods of securing, evaluating, and presenting data concerning household commodities. For home economics teachers in high schools, colleges, and adult classes.

524. Economic Problems of the Household (3) Economic problems of the present-day family; special emphasis on factors in household production, use of money income, and standards of living.

528. Home Management Supervision (2-3) Evaluation of objectives and tech

niques in organization, supervision, and teaching of the home management house experience.

543. Home Management in Relation to Family Living (3) Includes work with families in solution of their management problems.

544. Problems in Family Economics and Home Management (1-6) Investigation of selected problems in family economics and home management.

550. Seminar in Family Economics and Home Management (1-6) Discussion and reports on developments in family economics and home management.

FOOD SERVICE AND HOUSING ADMINISTRATION

S. Earl Thompson
Head of the Department of Hotel and Institution Administration
4A Human Development Building

Degrees Conferred: M.S., M.Ed.

Graduate work in this field trains for management positions in institutions which provide food service and housing to large groups, such as hospitals, residence halls, children's homes, and other public and private organizations. For admission, a student should have a baccalaureate degree in this or a related field.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (2)
410. Advanced Quantity Food Production (3)
425. Food and Labor Management and Control (3)
461. Personnel Functions in Food Service and Housing Administration (3)
470. Problems in Food Service and Housing Administration (3)

502. Problems in Institution Administration (3-6) Individual study of problems in institution administration. Prerequisites: F.S.H.A. 310, 330.

FOODS AND NUTRITION

George P. Barron, *Head of the Department*
202B Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., and M.Ed. in Foods and Nutrition; M.S. in Nutrition in Public Health.
Graduate Faculty: Senior Members—Professors Barron, Gordon, and Pike.

Graduate programs in foods and nutrition prepare students for careers in college teaching, research, and adult program leadership. The program in nutrition in public health prepares the student for work in public health agencies.

For admission to a graduate program in foods and nutrition, a student must have completed at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 3 in physiology, 4 in other physical and biological sciences, and 6 in foods and nutrition.

For admission to the program in nutrition in public health, the requirements are at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 12 in social sciences, 7 in foods, and 4 in nutrition.

FOODS AND NUTRITION (F N)

400. Special Problems in Foods and Nutrition (1-3)
420. Experimental Cookery (3)
421. Cultural and Aesthetic Aspects of Food (3)
422. Scientific Principles of Food Preparation (3) *Miss Gordon*
452. Nutritional Aspects of Disease (3) *Miss Pike*
456. Nutrition in the Community (3)
457. Principles of Nutrition (3) *Mr. Cox*
458. Applied Nutrition (2)
459. Advanced Nutrition (3) *Mr. Cox*
490. Foods and Nutrition Seminar (1)

520. Readings in Foods (2) Critical review and reports of literature on selected food topics. *Miss Gordon*

521. Seminar in Foods (1-6) Discussion and reports on current research in the foods field. *Miss Gordon*

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation. *Miss Gordon*

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

552. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy. *Miss Pike*

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged.

556. The Survey Method in Foods and Nutrition (2) Study of survey technique as a tool in the assay of food adequacy and nutritional status.

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition. *Miss Pike*

FORESTRY

Wilber W. Ward
Director of the School of Forest Resources
101 Forestry Building

Degrees Conferred: M.S., M.F.

Graduate Faculty: Senior Members—Professors Fletcher, Norton, and Ward; Associate Professors George, Gerhold, and Shipman; Assistant Professor Sopper. Associate Members—Professor Bartoo; Associate Professor Hutnik; Assistant Professor Borden, Elers, Lindzey, and Murphey.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science. The M.F. and M.S. degrees may be granted in the technological programs and the M.S. degree in the scientific programs.

Attention is called to the Ph.D. programs available in such related fields as agricultural economics, agronomy, botany, entomology, genetics, and plant pathology.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in timber management, wildlife habitat management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar program emphasizing biological science, economics, and applied mathematics provides the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engineering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

FORESTRY (FOR)

416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
445. Improvements (3)
450. Advanced Mensuration (3)
455. Forest Photo Interpretation (3)
466. Forest Resource Management (3)
469. (W.U. 469) Problems in Forestry and Forest Products (1-6 per term)
480. Policy and Administration (3)

504. (W.U. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 78.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Bot. 516.

510. Forestry Seminar (1 per term) Current problems of forest research presented as weekly seminar reports. May be repeated with additional credit for each term's work.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegeta-

tive propagation of trees. Prerequisite: Bot. 22.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 78, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 70.

WOOD UTILIZATION (W U)

404. Physical and Mechanical Properties of Wood (3)
405. Adhesives and Glued Wood Products (3)
424. Commercial Tropical Woods (3)
435. Seasoning and Preservation (3)
437. Wood Micro-Technique (3)
462. Defects in Wood (3)
469. (For. 469) Problems in Forestry and Forest Products (1-6 per term)
491. Logging and Lumbering (3)
492. Lumber Properties and Usage (3)
495. Lumber Manufacturing Processes and Cost Analysis (3)
497. Small Sawmills (3)

502. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose. Pulping quality, fiber measurements.

504. (For. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

510. Wood Utilization Seminar (1 per term)

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

540. Chemical Utilization of Wood (3) Wood as a chemical raw material; its chemical properties and conversion processes.

FRENCH

Gérard J. Brault, *Head of the Department*
210 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Senior Members—Professors Belasco, Brault, Chapman, Eyer, Hyslop, and LeSage.

The minimum requirement for admission to an advanced degree program will normally be 27 credits of post-intermediate work in language and literature. A student may follow a graduate program in French literature and in descriptive and historical linguistics with a minor in a related field. M.A. candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

FRENCH (FR)

417. French Phonology (3)
418. French Morphology and Syntax (3)
422. Old French Literature (3)
426. French Literature of the Renaissance (3)
435-436. 17th Century French Literature (3 each)
445. The Age of Enlightenment (3)
451-452. 19th Century French Literature (3 each)
460. French Prose of the 20th Century (3)
461. French Poetry and Drama of the 20th Century (3)
470. Advanced Composition and Conversation (3)
480. The Teaching of French (4)
*489. French Institute (7-14)
491. Problems in French Literature (3-6)
499. Foreign Study in French (3)

†1G. Elementary French for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

500. An Introduction to Old French (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments.

502. Advanced Linguistics (3) Synchronic dialectology; tagmemic and transformational analysis of contemporary French spoken language and literary texts. Prerequisite: Fr. 418.

515. Medieval French Literature (3) Familiarizes the student with Old and Middle French texts from the earliest monuments to Villon.

525. French Renaissance Literature (3-6) The origins and development of French Renaissance literature with emphasis on Rabelais, Ronsard, DuBellay, and Montaigne.

532. French Drama of the Classical Period (3) Origins and development of French classical comedy and tragedy, emphasizing the works of Corneille, Racine, and Molière.

533. Seventeenth Century Prose and Poetry (3) The development of Classi-

* A maximum of 7 credits in one summer.
† No graduate credit is given for this course.

cism; its apogee and decline as seen in the works of major prose writers and poets.

543. Eighteenth Century French Literature and Thought (3-6) Voltaire, Rousseau, Diderot, and other major figures.

561. French Romanticism (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry.

569. Masters of 20th Century French Literature (3-6) Major literary figures of contemporary French literature.

581. Theory and Techniques of Teaching French (1-3)

596. Symbolism (3) The anti-positivistic tradition in 19th century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

597. Research Techniques and Bibliography in French Language and Literature (1-3)

598. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

FUEL SCIENCE

Peter H. Given, *Head of the Department*
316 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Given, Palmer, and Walker; Associate Professors Austin and Essenhigh; Assistant Professor Polansky. Associate Members—Associate Professor Vastola; Assistant Professor Becker.

Research facilities, well instrumented, are available for the study of high temperature gas reactions by shock-tube and other techniques, electrochemical kinetics of fuel cell and battery systems, reactions in plasmas and flames, physics and chemistry of carbons and graphites, fundamental processes in the combustion of liquid and solid fuels, mass spectrometric investigation of the structure of solids, comminution of brittle materials, and the organic geochemistry of plant-derived sediments. Students can plan a wide variety of programs of study, to suit individual needs; coherent interdisciplinary programs are encouraged.

Students may be accepted with a B.S. or M.S. degree in chemistry, physics, chemical, aeronautical or mechanical engineering, or fuel science.

A basic minimum of 30 course credits is required for the Ph.D. degree, of which at least 12 must be in departmental courses.

FUEL SCIENCE (F SC)

400. Fuel Science Research and Design (1-10 per term)
410. Fuel Science Laboratory (1) *Mr. Polansky and Staff*
411. Mathematical Modelling for Fuel Scientists (3)
421. Flames (3)

422. Combustion Engineering (3)
423. Combustion Laboratory and Field Trips (1)
424. Energy in Space Travel (3)
425. Selected Topics in Fuel Science (3)

503. Coalification and Coal Chemistry (3) Chemical changes during the coalification process; chemical and physical constitution and classification of coals; relations between coal chemistry and constitution. Prerequisite: Chem. 31. *Mr. Given*

506. Kinetics of Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of coals and carbons. Prerequisite: Chem. 451. *Mr. Walker*

510. Special Topics in Fuel Science (1-6 per term)

511. Fuel Science Seminar (1 per term) Selected topics from current research relevant to fuel science.

512. High Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.Sc. 421. *Mr. Palmer*

515. Catalysis of Fuel Reactions (2) Principles of chemisorption and catalysis; mechanisms of specific catalytic reactions and practical aspects of catalytic processes in the fuels industries. Prerequisite: Chem. 452. *Mr. Walker*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in fuel science studies are listed under Mineral Sciences.*

GENERAL ENGINEERING

Otis E. Lancaster
Chairman of the Committee on General Engineering
101 Hammond Building

Degrees Conferred: M.Ed., M.Eng.

This program is designed primarily to meet the needs of the engineering faculty in the various technical institutes. The objective is to give academic preparation to those individuals who will teach engineering subjects at the two-year college level.

For admission an undergraduate degree in engineering, physical science, mathematics, or the equivalent is required.

For either degree a minimum of 30 credits is required in addition to a scholarly written report. Twenty-four of these credits should be in engineering, physics, and mathematics. A candidate is expected to earn at least 3 credits each in mathematics, physics, and two fields of engineering, or demonstrate competence in them.

For the M.Ed. 6 credits must be in education, consisting of one 3-credit course in the theory of learning and teaching and one 3-credit course in internship in college teaching. Fifteen credits must be earned at the 500 level.

For the M.Eng. degree 6 credits may be taken in any field approved by the committee but at least 12 credits in engineering subjects must be at the 500 level.

GENERAL FAMILY STUDIES

Rose M. Cologne
In Charge of Graduate Programs in General Family Studies
20A Human Development Building

Degrees Conferred: M.S., M.Ed.

Because this program is planned for teachers in secondary schools or small college and others who wish to become proficient in several areas of home economics, th student must have a strong home economics background for admission.

The major for the M.S. or M.Ed. degree consists of a minimum of 6 credits in eac of three areas of home economics. The student chooses a minor field of educationa foundations or, if sufficient competence in educational foundations is demonstrated one of the applied fields, such as home economics education, secondary education, o higher education.

GENERAL FAMILY STUDIES (G F S)

410. Communities and Families (3)

516, 516v. Methods of Research in Home Economics (3) Review of problem and techniques of research in home economics. Required of all graduate student in home economics.

GENETICS

James E. Wright, *Chairman of the Committee on Genetics*
307 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Buss, Grun, W. I. Thomas, D. E Walker, J. E. Wright, and Zimmerman; Associate Professors Cleveland, Gerhold Hicks, and Starling; Assistant Professor Creech. Associate Members—Associate Pro fessors Person and Pfeiffer; Assistant Professor Craig.

Graduate programs are offered in the fields of theoretical and applied genetics including plant and animal breeding. Courses in genetics and breeding are given by various departments. The basic and theoretical courses are listed under identica numbers in the Departments of Botany and Zoology. Courses dealing with genetic principles as applied to specific organisms are offered in the Departments of Agron omy, Animal Science, Dairy Science, Forest Management, Horticulture, Microbiology and Poultry Science. The graduate committee for majors shall be appropriately represented by members of theoretical and applied phases who shall have the re sponsibility and jurisdiction for determining course work and research acceptable in satisfying degree requirements.

For entry as a major in this field no fewer than 15 credits in basic biology and 15 credits in the areas of chemistry, mathematics, and physics are required.

The following courses are available in genetics or breeding, and their description may be found under the offerings of the several departments: Agro. 411, 509, 510 582; A.I. 501, 505; An.Sc. 422; Bot. (Zool.) 405, 422, 505, 524, 528, 533; D.Sc 513; For. 512; Hort. 407, 444, 501, 514, 520, 524; Micrb. 516; Pty.Sc. 402, 505.

GEOCHEMISTRY

John C. Griffiths
Head of the Department of Geochemistry and Mineralogy
204 Deike Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Brindley, Burnham, Greig, Griffiths, Keith, Osborn, Roy, Vand, and Wright; Associate Professors Barnes, Dachille, Herzog, and Thornton; Mrs. Roy. Associate Members—Assistant Professors Hsu, Weber, and White.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOCHEMISTRY (GCHEM)

457. Geochemical Prospecting (2)

501. Research (1-10 per term) Research in geochemistry.

509. Geochemistry Seminar (1 per term)

510. Problems in Geochemistry (1-9) Laboratory and library study of special problems.

512. Crystal Chemistry of Nonmetallic and Defect Solids (2-4) Relation of structure to ionic size, charge, polarizability; influence of p-t environment; chemical-structural defects, diffusion, transitions, and reactions in solids. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams.

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Weber*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Herzog*

518. Isotope-Ratio Variations in Nature (2) Theoretical basis and observations of isotope fractionation in nature: paleotemperature scale; temperatures of formation of ore deposits and other rocks. *Mr. Weber*

519. Cosmochemistry and Nucleogenesis (2) Distribution and composition of

matter; origin of solar system and earth, of constituent nuclides, of life. *Mr. Herzog*

520. P-T-X Phase Relations in Mineral Systems (2) Phase equilibrium in mineral systems with pressure as a variable. Prerequisite: Gchem. 513.

522. Geochemistry of Aqueous Systems (3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, P_{O_2}-pH relations applied to ground water, sea water, hydrothermal fluids. *Messrs. Barnes and Schmalz*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Mineral Sciences.*

GEOGRAPHY

Allan L. Rodgers, *Head of the Department*
403 Deike Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Deasy, Miller, Rodgers, and Zelinsky; Associate Professors Gould and Wernstedt. Associate Members—Professor Lewis; Associate Professor Simkins.

The student may concentrate on economic geography, cultural geography, physical geography, one of the major world regions, or acceptable combinations of these fields. In addition, all students receive training in cartographic, statistical, and bibliographic techniques.

Because physical geography is a branch of the physical sciences, and cultural and economic geography are branches of the social sciences, a student may enter graduate work under either of two options. Option 1, for the student who wishes to specialize in physical geography, requires the completion of 18 undergraduate credits in geography and 20 credits in mathematics and biological and physical sciences, including at least 6 credits in geology. Option 2, for the student who wishes to specialize in cultural or economic geography, requires 18 undergraduate credits in geography plus 20 credits in the social sciences, including at least 3 in economics.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Zelinsky*
402. Cultural and Anthropo-Geography (3) *Mr. Zelinsky*
405. Geography of Population (3) *Mr. Zelinsky or Mr. Simkins*
407. Geography of Settlement (3) *Mr. Simkins*
410. Cartography—Map Design and Construction (3) *Mr. Deasy*
420. Urban Geography (3) *Mr. Rodgers*
427. Geography of the Soviet Union (3) *Mr. Rodgers*
430. Agricultural Geography (3) *Mr. Whitney*
433. Regional Climatology (3) *Mr. Wernstedt*
434. Regional Physiography (3) *Mr. Lewis*
442. Geography of Europe (3) *Mr. Miller*
443. Geography of the Orient (3) *Mr. Whitney*
444. Geography of Africa (3) *Mr. Gould*
445. Geography of Southern Asia (3) *Mr. Wernstedt*
452. Interpretation of Aerial Photographs (3) *Mr. Deasy*
456. Quantitative Methods of Geographical Analysis (3) *Mr. Gould*
460. Political Geography (3) *Mr. Lewis*

468. Transportation Geography (3) *Mr. Gould*
480. Geography of Manufacturing (3) *Mr. Miller or Mr. Rodgers*
490. Physical Geography for Teachers: Landforms (3) *Mr. Lewis*
491. Physical Geography for Teachers: Regional Climatology (3) *Mr. Wernstedt*

500. Introduction to Geographic Research (3)

501. Geographic Bibliography (1) An introduction to the techniques of bibliographic search and the writing of research papers in geography. Prerequisite: Geog. 500.

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The literature of some phase of physical geography with emphasis on procedures for organizing material for classroom reports and discussions.

505. Economic Geography Seminar (3-12) The literature of some phase of economic geography with emphasis on procedures for organizing material for classroom reports and discussions.

506. Cultural and Political Geography Seminar (3-12) The literature of some phase of cultural and political geography with emphasis on procedures for organizing material for classroom reports and discussions.

507. Development of Geographic Thought (1-6) Critical analysis of the growth of geographic thought from antiquity to the present; emphasis on structure of modern geography.

509. Population Geography Seminar (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

510. Physical Geography Research (3-10) Original study in physical geography: a field problem or detailed library investigation with analysis and presentation of data.

511. Economic Geography Research (3-10) Original study in economic geography: a field problem or detailed library investigation with analysis and presentation of data.

512. Cultural and Political Geography Research (3-10) Original study in cultural and political geography: a field problem or detailed library investigation with analysis and presentation of data.

543. Conceptual Frameworks for Geographical Analysis (3) Simulation, topological, queuing, programming, principal component, and game theory models in solving geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

GEOLOGY

Lauren A. Wright
Head of the Department of Geology and Geophysics
303 Deike Building

Degrees Conferred: Ph.D., M.S.

GEOLOGY

Graduate Faculty: Senior Members—Professors Lattman, Ridge, Scholten, Spackman, Williams, and Wright; Associate Professor Schmalz. Associate Members—Associate Professor Parizek; Assistant Professors Dutcher, Guber, and Voight.

Students may specialize in stratigraphy, paleontology, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, marine geology and chemical oceanography, coal geology, and geology of metallic and nonmetallic deposits.

Prerequisites for admission include 25 credits in an approved combination of chemistry, physics, mathematics, and biological sciences, and at least 18 credits in geology and mineralogy.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOLOGY (GEOL)

400. Surface Geological Processes for Teachers (3)
401. Earth History for Teachers (3)
402. Field Methods for Teachers (3)
410. Structural Geology (3) — *Mr. Gold*
420. Paleobotany (3) — *Mr. Spackman*
421. Introduction to Coal Petrology (3) — *Mr. Williams*
422. Introductory Palynology (3) — *Mr. Spackman*
430. Paleontology (3) — *Mr. Guber*
440. Marine Geology (3) — *Mr. Schmalz*
451. Economic Geology (3) — *Mr. Ridge*
452. Introduction to Hydrogeology (3) — *Mr. Parizek*
453. Principles of Engineering Geology (3) — *Mr. Voight*
461. Geology of North America (3-6) — *Mr. Wright*
462. Principles of Geomorphology (3-6) — *Mr. Lattman*
470. Introduction to Field Geology (3)
472. Field Geology (5) — *Mr. Scholten*
481. Geology of Oil and Gas (3) — *Mr. Scholten*
490. Stratigraphy (4) — *Mr. Williams*

*500. Geology Seminar (1-9) Presentation, at weekly departmental meetings, of topics selected from geological literature.

†501. Stratigraphy (3-12) Principles of stratigraphic classification, lithofacies and biofacies, faunal zonation, correlation, sedimentation, and paleogeography, illustrated by stratigraphy of classical geologic regions: (a) Pre-Cambrian; (b) Paleozoic; (c) Mesozoic; (d) Cenozoic. Prerequisite: Geol. 430. *Mr. Williams*

†503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Guber*

504. History and Foundations of Geology (2-4) Theoretical aspects of geology; spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology. *Mr. Lattman*

511. Ore Deposits: Principles (3-6) Geological and geochemical processes con-

* Credits to be arranged, 1 to 6 per term.
† Credits to be arranged, 3 to 6 per term.

trolling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

515. Ore Microscopy (2-3) Theory and use of the ore microscope in identifying ore minerals in polished section, establishing paragenetic sequences, determining manner of deposition. *Mr. Barnes*

‡517. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Mr. Williams*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Mr. Spackman*

526. Problems in Palynology (3-9) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Spackman*

530. Geological Problems (1-15) Prerequisite: 10 credits in geology and mineralogy.

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Lattman*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462. *Mr. Lattman*

551. Geotectonics (3-6) Tectonic principles and elements: nature and development of geosynclines, island arcs, mountain structures, stable masses, cratons, mobile belts. *Mr. Scholten*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and microscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

571. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

590. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Mineral Sciences.*

‡ Credits to be arranged, 2-3 per term.

GEOPHYSICS

Lauren A. Wright
Head of the Department of Geology and Geophysics
303 Deike Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Bell and Howell; Associate Professor Herzog. Associate Members—Assistant Professors Alexander and Lavin.

Students may specialize in geophysical surveying, seismology, gravity, space applications of geophysics, tectonics, physical properties of rocks, radioactive age determinations, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOPHYSICS (GPHYS)

400. Physics of the Earth for Teachers (3)
406. Physics of the Earth (3) *Mr. Howel*
407. Well Logging (3)
408. Geophysical Surveying (3) *Mr. Lavin*
415. Gravity and Magnetic Surveying (3)
416. Electrical Surveying (3) *Mr. Lavin*
417. Seismic Methods (3) *Mr. Lavin*
418. Potential Theory Applied to Earth Problems (3) *Mr. Alexande*

500. Geophysical Seminar (1 per term) Discussion of geophysical reports and papers; scientific outlook.

501. Research (1-10 per term) Research in geophysics.

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders. *Mr. Howel*

503. Special Studies in Geophysics (1-9) Special studies of the theories of geophysical methods.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting. *Mr. Alexande*

508. Tectonics (3) Seminar in the cause and nature of the principal deformation of the earth.

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration. *Messrs. Herzog and H. D. Wrigh*

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineral Sciences.*

GERMAN

Stanley R. Townsend, *Head of the Department*
105 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.
Graduate Faculty: Senior Members—Professors Ebbinghaus, Shelley, and Townsend; Associate Professor Striedieck. Associate Members—Professor de Levie; Assistant Professors Hohendahl and Kopp.

There is opportunity for major emphasis upon either literature or philology. Minimum qualifications for admission include 18 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies.

A thesis is required of all M.A. candidates in this major.

GERMAN (GER)

401. Advanced Stylistics (3)
430. History of the German Language (3)
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3)
469. Goethe's Life and Works (3)
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.

* No graduate credit is given for this course.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

524. Old Saxon (3) Introduction to Old Saxon grammar; readings in Old Saxon texts, both prose and poetry. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

HIGHER EDUCATION

Robert E. Sweitzer, *in Charge of Graduate Programs in Higher Education*
113 Education and Psychology Center, Building II

Degrees Conferred: D.Ed., M.Ed.
Graduate Faculty: Senior Members—Professors Edgar, Patrick, Sweitzer, and Wellington.

Graduate students with any undergraduate major may enter the program without other prerequisites. The following courses in higher education are listed under the offerings of the Department of Educational Services: Ed.Ser. 545 to 552 inclusive and 555 (see page 109). To complete a program to meet the student's needs, additional courses will be selected from other departments of the University.

This program is designed to prepare candidates for such positions as college instructor in professional education, college administrator, director of special divisions in education, or educational research worker. It is not open to students who are preparing to give instruction in the arts, humanities, sciences, etc. However, candidates for advanced degrees in fields other than higher education may elect it as a minor, subject to the restrictions concerning minors.

Candidates who have not had teaching experience or other approved educational experience will be required to complete an approved apprenticeship before the degree will be conferred.

HISTORY

Robert K. Murray, *Head of the Department*
116 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Senior Members—Professors Brown, Dahmus, Forster, Hassler, Hoogenboom, Klein, McNall, Murray, and Thaden. Associate Members—Professor Green; Associate Professors Ameringer, Frantz, Meier, Pixton, and Sun; Assistant Professors Eggert, Enteen, and Linker.

Graduate work is offered in the following fields of history: ancient, medieval, early modern European, modern European, colonial American, 19th century American, modern American, British, Russian, Latin American, Far Eastern, Middle Eastern, political (European or American), diplomatic (European or American), economic (European or American), social and cultural (European or American).

The candidate for the doctor's degree must pass examinations in four of the above fields, one of which is his dissertation field. He must also pass an examination either in a fifth field of history and a single cognate field, or in a study area made up of a number of academic disciplines related to his dissertation field. The candidate for the master's degree selects one broad field (such as modern European or American) for examination and thesis purposes. About half his course credits are selected outside the examination field. He also must take work in a cognate field. A thesis is required of all M.A. candidates in this major.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. All applicants must provide Graduate Record Examination scores with their applications.

All students are advised that individual instructors may require a reading knowledge of pertinent languages for seminar work and for research on thesis topics.

HISTORY (HIST)

401.	Classical Civilization (3)	*Mr. Borza*
403.	The Middle Ages from Constantine to the Crusades (3)	*Mr. Dahmus*
404.	The Middle Ages from the Crusades to the Renaissance (3)	*Mr. Dahmus*
408.	Intellectual History of the Middle Ages (3)	*Mr. Dahmus*
410.	Renaissance and Reformation (3)	*Mr. Green*
413.	The Age of Absolutism (3)	*Mr. Green*
417.	Nineteenth Century Europe (3)	
419.	Recent European History (3)	*Mr. Forster*
422.	History of the American Frontier (3)	*Mr. McNall*
425.	History of American Political Parties (3)	*Mr. Hoogenboom*
427.	The Diplomatic History of the United States (3)	
428.	American Military History (3)	*Mr. Hassler*
430.	Colonial America to 1753 (3)	
431.	Revolutionary America, 1753-1783 (3)	*Mr. Frantz*
432.	The Formative Period of American History (3)	*Mr. Brown*
433.	The Middle Period of American History (3)	*Mr. Klein*
434.	The United States in Civil War and Reconstruction (3)	*Mr. Hassler*
435.	The Emergence of Modern America (3)	*Messrs. Murray and Hoogenboom*
436.	Recent American History (3)	*Mr. Murray*
439.	History of England in the Middle Ages (3)	*Mr. Dahmus*
440.	Britain Under the Tudors and Stuarts, 1485-1688 (3)	

441. Great Britain, 1688-1832 (3)
442. History of Russia to 1801 (3) *Mr. Thaden*
443. History of Russia, 1801-1917 (3) *Mr. Thaden*
444. Eastern Europe in Modern Times (3) *Mr. Thaden*
447. Social and Economic History of Europe Since 1750 (3) *Mr. Silverman*
448. Intellectual and Cultural History of Modern Europe (3) *Mr. Silverman*
449. Diplomatic History of Europe Since 1870 (3) *Mr. Forster*
452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
454. Economic Development of the United States (3) *Mr. Eggert*
456. History of American Labor (3) *Mr. Eggert*
460. Latin America and the United States (3) *Mr. Ameringer*
461. Social and Cultural History of Latin America (3) *Mr. Ameringer*
467. Alexander the Great and the Hellenistic World (3) *Mr. Borza*
468. The Roman Republic (3) *Mr. Borza*
469. The Pax Romana (3) *Mr. Borza*
471. History of Modern China (3) *Mrs. Sun*
472. Twentieth Century China (3) *Mrs. Sun*
481. The Middle East in Modern Times (3) *Mr. Goldschmidt*
491. History of the Soviet Union (3) *Mr. Enteen*
492. Great Britain Since 1832 (3)
498. Selected Topics in History (3-6)

501. Historical Method (3) *Mr. Meier*
502. Historiography (3) *Mr. Meier*
504. Medieval Civilization (3-9) *Mr. Dahmus*
505. The Age of the Reformation (3-6) *Mr. Green*
508. Studies in European History, 1600-1789 (3-6)
509. Europe Since 1789 (3-6) *Mr. Forster*
512. Studies in Pennsylvania History (3-6) *Mr. Klein*
520. Colonial and Revolutionary America (3-6) *Mr. Frantz*
533. The United States, 1783-1860 (3-6) *Mr. Klein*
534. The United States, 1860-1877 (3-6) *Messrs. Brown and Hassler*
535. The United States, 1877-1919 (3-6)
536. The United States Since 1919 (3-6) *Messrs. Murray and Hoogenboom*
538. Diplomatic History of the United States (3)
539. Economic History of the United States (3) *Messrs. McNall and Eggert*
540. Studies in British History (3-6) *Mr. Linker*
544. Seminar in Eastern European History (3-6) *Mr. Thaden*
545. Studies in Russian and Soviet History (3-6) *Messrs. Thaden and Enteen*
550. Problems in History (3-6)
552. Cultural History of the United States (3)
562. Seminar in Latin-American History (3-6) *Mr. Ameringer*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Ameringer*

599. Readings in History (1-6)

HOME ART

William J. McHale, *Chairman of the Division*
S—258 Human Development Building

A candidate for an advanced degree may choose a minor in home art upon approval by his major department. However, no advanced degree is offered in this field.

FAMILY HOUSING AND HOME ART (FH HAR)

401. Home Furnishings for the Family (3)
*433. Advanced Home Crafts (2-12)
440. Advanced Home Furnishing Problems (3)
441. Special Problems in Home Furnishings (3)
470. Housing Problems and Policies (3)

515. Backgrounds of the Home Arts (3) Evaluation of useful objects in respect to their form, function, and time; selections for exhibition.

530. Problems in Family Housing and Home Art (1-6) Individual investigation, analysis, and presentation.

541. Art in the Environment (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

HOME ECONOMICS EDUCATION

Marjorie East, *Head of the Department*
114 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors East and Hatcher. Associate Member—Associate Professor Ray.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

For admission the student must present approximately 50 credits of undergraduate work from the following areas: home economics education, education and/or psychology, aspects of home economics; the physical and biological sciences; and the social sciences.

* Not more than 2 credits in each field.

HOME ECONOMICS EDUCATION (HE ED)

400, 400v. Special Problems in Home Economics Education (1-3)
406, 406v. Audio-Visual Methods for Home Economics (1-4)
410v. Supervision of Student Teachers (1-3)
427, 427v. Teaching Home Economics (3)
443, 443v. Adult Education in Home Economics (3)
463, 463v. Senior Seminar (2)
466, 466v. Student Teaching (9)
477, 477v. Curriculum Development for Home Economics in Secondary Schools (3)
478, 478v. Appraising Student Progress in Home Economics (3)
479, 479v. Readings in Home Economics Education (1-4)
480, 480v. Problems in Teaching Home Economics (3-6)

502, 502v. Home Economics Instruction at the College Level (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers. *Mrs. East*

503, 503v. Home Economics Teacher Education (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics. *Miss Hatcher*

504, 504v. Educational Issues and Home Economics (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience. *Mrs. East*

510, 510v. Educational Leadership in Home Economics (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics. *Mrs. East*

511, 511v. Internship in Home Economics Supervision and Administration (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision. *Miss Hatcher*

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE

Darrell E. Walker, *Head of the Department*
101 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members—Professors Fleming, Hitz, Larson, Meahl, Odland, Smith, and Walker; Associate Professors McArdle, Ritter, and Tukey; Assistant Professor Creech. Associate Members—Professor Mastalerz; Associate Professors Bergman and Pfahl; Assistant Professors Craig, Haramaki, and White.

Students may specialize in propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various environmental and post-harvest physiological studies of horticultural crop species.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, plant nutrition, or pomology should register for **Hort. 501.**

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, and biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

HORTICULTURE (HORT)

401. Plant Propagation (3) *Mr. Haramaki*
402. Plant Nutrition (3) *Mr. Bergman*
403. Horticultural Plants and Their Environment (3) *Mr. Mastalerz*
404. Advanced Horticultural Crop Science (3-12) *Mr. Walker*
405. Senior Seminar in Horticulture (1-2)
407. Plant Breeding (3) *Mr. Creech*
412. Post-Harvest Physiology (3) *Mr. Ritter*
444. Advanced Plant Breeding (3-6) *Mr. Craig*
447. Problems in Horticulture (1-9)
451. Flower Store Management (4) *Mr. Pfahl*

500. Ecology of Fruit Plants (3) Factors limiting the distribution and intensity of culture of fruit species and varieties and effect of environmental factors on cultural practices. Spring term, even years. *Mr. Tukey*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology. *Mr. Walker*

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. Winter term, odd years. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Mr. Meahl*

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3) *Mr. Craig*

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years. *Mr. Tukey*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

INDUSTRIAL ARTS EDUCATION

JOHN WITHALL, *Head of the Department of Secondary Education*
164 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professor McGarey; Associate Professor Pendered.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

INDUSTRIAL ARTS (I ART)

400. SHOP MANAGEMENT AND LAYOUT (3)
407. CURRICULUM MATERIALS AND METHODS IN INDUSTRIAL ARTS (4)
470. PROBLEMS IN SENIOR HIGH SCHOOL INDUSTRIAL ARTS (3)

574. HISTORY AND PHILOSOPHY OF INDUSTRIAL ARTS (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. PROBLEMS IN INDUSTRIAL ARTS EDUCATION (2-3) Subject matter, projects, methods of manual and informational teaching, aids and devices, selection of text and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. SUPERVISION AND ADMINISTRATION OF INDUSTRIAL ARTS EDUCATION (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. TESTING IN INDUSTRIAL ARTS (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and grading; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. RESEARCH IN INDUSTRIAL ARTS (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. SEMINAR IN INDUSTRIAL ARTS (2-9) Directed intensive study, investigation, or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING

BENJAMIN W. NIEBEL, *Head of the Department*
207 Hammond Building

Degrees Conferred: M.S., M.Eng.

Graduate Faculty: Senior Members—Professors Lancaster, Niebel, and Schmidt; Associate Professor Ham. Associate Members—Professor Thuering; Assistant Professors Draper, Guild, and Raphael.

Graduate study and research are conducted in management science, process design, systems engineering, and human engineering.

For admission a student must have a bachelor's degree in industrial engineering. Graduates of other accredited engineering majors may be admitted after completing basic work in industrial engineering.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
402. Engineering Economy (3)
403. Engineering Economy and Statistics (3)
404. Management Science (3)
405. Quantitative Methods in Industrial Engineering III (3)
406. Design of Production Systems (3)
422a,b,c,d,e,f. Industrial Engineering Problems (2-12)
423. Quality Control (3)
424. Job Evaluation (3)
425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Advanced Metal Casting (3)
428. Foundry Engineering (3)
430. Industrial Leadership (3)
432. Industrial Engineering Lectures (1-3)
438. Metal Cutting Principles and Practice (3)

501. Manufacturing Methods (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. Management Methods (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. Industrial Relations (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 43 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Budgetary Control and Standard Costs (3-6) Divisional budgets as control media; establishing standard cost data, standard cost accounting procedures, and the use of cost variances in controlling manufacturing operations. Prerequisite: I.E. 335.

508. Methods of Operations Research (3) Analytical approach to management decision-making including decision theory, game theory, constrained extremum theory; minimum cost transportation and network models. Prerequisites: Math. 100 and 3 credits in statistics.

509. Methods of Operations Research (3) Theory and application in decision-

making including sequencing, line balancing, inventory, replacement, waiting line models, and Monte Carlo simulation. Prerequisites: Math. 100 and 3 credits in statistics.

510. Methods of Operations Research (3) Theory and application of mathematical programming including linear and dynamic programming, and an introduction to nonlinear, integer, and stochastic programming. Prerequisite: Math. 100.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 44 and 3 credits in statistics.

513. Data Processing and Programming (3) Theory and techniques in systems analyses applied to the programming of procedures and operations.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

JOURNALISM

Robert M. Pockrass, *in Charge of Graduate Programs in Journalism*
214 Carnegie Building

Degree Conferred: M.A.
Graduate Faculty: Senior Member—Professor Marbut. Associate Members—Professors Brown and Goodwin; Associate Professors Froke, Harrison, Norris, Pockrass, and Schulte; Assistant Professor Preston.

The program is designed to give students an understanding of the theory and practice of mass communication, a critical insight into the structure and functions of mass communications industries, an introduction to research on communications problems, and an opportunity to acquire some depth in a minor field of study. Fulfilling the requirements for this degree should qualify students to advance in positions of responsibility and leadership in the professions of journalism, advertising, broadcasting, and public relations; or in communications education and research.

The program is designed primarily for students who have had some professional courses or experience in journalism and mass communications. Other students will be required to complete a series of at least three undergraduate courses.

A thesis and a minor of 12 credits are required of all M.A. candidates in this major.

JOURNALISM (JOURN)

401. Critics and Ethics of the Mass Media (3) *Mr. Harrison*
405. Comparative Foreign Journalism (2) *Mr. Schulte*
406. Evaluation and Uses of Mass Communications Research (3) *Mr. Preston*
421. Editorial Interpretation (3) *Messrs. Harrison and Brown*
422. Cultural Aspects of the Mass Media (3) *Mr. Pockrass*
424. Public Affairs Reporting (3) *Mr. Dulaney*

430. Journalism in the Schools (3-6) *Mr. Vairo*
442. Special Topics in Advertising (3)
443. Advertising Campaigns (3) *Mr. Rotzoll*
444. Advertising in Contemporary Society (3) *Mr. Norris*
466. Public Relations Problems (3) *Mr. Vairo*
468. Law of Mass Communications (3) *Mr. Smith*
481. News Evaluation and Presentation (3) *Mr. Harrison*
492. (Brcst. 492) Public Affairs Broadcasting (3)
499. Independent Study in Mass Communication (2-6) *Mr. Goodwin*

504. Seminar in the History of Mass Communication (3) *Mr. Schulte*

505. International Communication Problems (3) Legal and communications problems of the international flow of news and opinion; international press codes. *Mr. Marbut*

506. Seminar in Communications Research (3-6) Methodology of research in media, content, audiences; experimental, case, and field studies; data processing and analysis; report writing; individual projects. *Mr. Preston*

508. The Literature of Journalism (3) *Mr. Brown*

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Goodwin*

540. Seminar in Advertising Problems (3) *Mr. Norris*

585. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*

MATHEMATICS

James B. Bartoo, *Head of the Department*
228 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Senior Members—Professors Anderson, R. Ayoub, Benton, S. Chowla, Curry, N. Fine, A. Frink, O. Frink, Hunter, Kanwal, H. Krall, Mitchell, Mrowka, Patil, Riberio, Schoenfeld, Selfridge, and Sheffer; Associate Professors Axt, Gratzer, Harkness, D. G. Johnson, and Kist; Assistant Professor M. Petrich. Associate Members—Professor Bartoo; Associate Professors C. Ayoub, Mack, and McCammon; Assistant Professors Barnes, Bouwsma, Comstock, A. Krall, Rung, Stevens, and Wegner.

Graduate courses in all the principal branches of mathematics are offered each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, statistics, numerical

analysis, applied analysis, and mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

To be admitted to the M.A. or Ph.D. program without undergraduate deficiency, an applicant should have completed at least three courses in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) *and* 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree.

For the M.A. degree the department offers two options:

(1) The *thesis* option requires 12 credits of 500-series courses, 6-9 credits of thesis, sufficient credits in approved 400-series courses to make a total of 30 credits, and a final (oral) examination based on the thesis and general course material.

(2) The *non-thesis* option requires 18 credits of 500-series courses in mathematics with grades of A or B, sufficient credits in approved 400-series courses to make a total of 30 credits, and a term paper on an approved topic of mathematics. No final examination is given in this option.

All first-year students who are working toward the M.A. or Ph.D. degree are required to enroll in Math. 498 for two successive terms. All M.A. and Ph.D. students, before they have accumulated 48 graduate credits earned at this University or elsewhere, *must* take qualifying examinations in three fields of mathematics and a reading examination in French, German, or Russian. Recommendations for advancement to Ph.D. candidacy are based on these examinations. The comprehensive examination is given after approximately 60 credits and only after the student has passed a reading examination in a second of the foregoing languages.

To be admitted to the M.Ed. program without undergraduate deficiency in mathematics, an applicant should have at least 24 credits in mathematics including at least 6 at the intermediate level beyond calculus.

For the D.Ed. degree, a student must pass a reading examination in French, German, or Russian before he is allowed to take the comprehensive examination. In addition to the major thesis, the department requires a minor thesis on an assigned topic in mathematics.

Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 415, 416, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. and D.Ed. degrees.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. Fourier Series and Partial Differential Equations (3)
407. Foundations of Algebra and Geometry (3)
409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
413-414. Mathematics of Science for Teachers (3 each)
415. Survey of Modern Mathematics for Teachers (3)
416. Mathematical Logic for Teachers (3)
417. Tensor Analysis (3)
418. (Stat. 418) Introduction to Probability Theory (3)
419. Analytical Mechanics (3)
420-421. Introduction to Analysis (3 each)
428. (Phil. 428) Logical Theory (3)
431. Ordinary Differential Equations (3)
441. Matrix Algebra (3)
451. Functions of Several Variables (3)

452. Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elements of Set Theory and Topology (3)
480-481. Introduction to Modern Algebra (3 each)
491. Topics in Applied Mathematics (3-9)
498. Mathematics Seminar (1-6)

500. Analytical Mechanics (3) An exposition of rigid dynamics, the potential function, and Lagrange's equations. Prerequisite: Math. 419 or Phys. 461.

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisites: Math. 44, 421.

508-509. Theory of Functions of a Complex Variable (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisites: Math. 481 or 537.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

516. (Stat. 516) Intermediate Probability Theory (3) Random walk and recurrent events, Markov chains, and the simplest time-dependent stochastic processes. Prerequisite: Math. 418.

517-518. (Stat. 517-518) Advanced Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 501, 541.

520-521. Projective Geometry (3 each) General study of the subject from the postulational standpoint. Prerequisite: Math. 43. Alternate years or as required.

523. Metric Differential Geometry (3) The usual classical treatment of the subject. Prerequisite: Math. 43.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

529-530-531. Topology (2 each) Topological, product, compact, metric, and

connected spaces; continuous functions, separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

533. Analytic Theory of Numbers (2-6) Topics selected from Dirichlet's Theorem on primes in A. P., Riemann Zeta-function, distribution of primes, Waring's problem, Goldbach's problem, partitions. Prerequisites: Math. 404 or 480; Math. 508.

534. Elementary and Algebraic Number Theory (2-6) The arithmetic and ideal theory of higher algebraic number fields will be emphasized, together with the necessary rational number theory. Prerequisite: Math. 480.

535-536-537. Algebra (2 each) Basic theory of semigroups and groups, rings and modules, fields, lattices, and linear algebra. Prerequisite: Math. 106.

538-539-540. Rings and Homological Algebra (2 each) Selected topics including structure theory of rings and an introduction to categories and functions. Prerequisite: Math. 537.

541. (Stat. 541) Mathematical Statistical Analysis (3) Probability spaces, random variables, distribution and characteristic functions, convergence theorems, univariate and multivariate distribution theory. Prerequisite: Math. 421.

542-543. (Stat. 542-543) Advanced Theory of Statistics (3 each) Exact and asymptotic sampling distribution theory, rigorous treatment of sufficiency, completeness, estimation, and testing. Prerequisites: Math. 410, 541.

544-545-546. General Topology (2 each) Topics selected including uniform spaces, function spaces, and proximity spaces. Prerequisite: Math. 531.

547-548-549. Lie Theory (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

550-551. (Phil. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. Numerical Analysis (3) Approximate solution of discrete eigenvalue problems. Prerequisites: Math. 420, 481.

553. Numerical Analysis (3) Topics from interpolation and integration with remainder terms, approximation theory, asymptotic expansions, solutions of differential and integral equations. Prerequisites: Math. 421, 453.

554. (Phil. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Math. 428.

555. Selected Topics in Mathematics for Chemists (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions.

556. (Phil. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions, recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 428.

557. (Phil. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisites: Math. 554, 556.

560-561. Theory of Differential Equations (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solutions. Prerequisites: Math. 100, 508.

562. Theory of Special Functions (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 100 and either Math. 420 and Math. 452 or Math. 508.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. (Stat. 577) Special Topics in Probability and Statistics (3-12)

578. Special Topics in Topology (3-12)

579. Special Topics in Numerical Analysis (2-12)

*580. Special Topics in Number Theory (2-12)

581-582-583. Group Theory (2 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 537.

584-585-586. Algebraic Topology (2 each) Development of singular and Cech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

587-588-589. Point Set Topology (2 each) Topics selected from point set topology including upper semicontinuous and continuous decompositions, theory of continua, dimension theory. Prerequisite: Math. 531.

MECHANICAL ENGINEERING

Richard G. Cunningham, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

* Credits to be arranged, 2-3 per term.

MECHANICAL ENGINEERING

Graduate Faculty: Senior Members—Professors Ambrosius, Brickman, Calvert, Cunningham, DiIlio, Meyer, Olson, Queer, and Shearer; Associate Professors McLaughlin and Schmidt. Associate Members—Associate Professors DeCarolis, Lestz, Mundo, and Park; Assistant Professors Baker, Brighton, Heinsohn, and Wolgemuth.

Graduate programs and research facilities are available in dynamic system analysis and instrumentation, automatic controls, fluid amplifiers, combustion and ignition processes, heat transfer, thermodynamics, fluid mechanics, turbulence, machine dynamics, advanced design engineering, lubrication, power generation and utilization, and building research studies. In addition to basic facilities in the mechanical engineering laboratory, the department has several specialty research laboratories. They are: Systems and Controls Laboratory, Air Environment Laboratory, Dynamics Simulation Laboratory, and Automotive Safety Research Laboratory.

The entering student must hold a bachelor's degree in engineering or physical science. If his undergraduate work has not included considerable work in mechanical engineering subjects, he may be required to include these subjects in his program.

MECHANICAL ENGINEERING (M E)

401. Mechanical Engineering (3-12)
402. Air Conditioning and Life Support Systems (3)
403. Rocket Propulsion (3)
405. Small Particle Technology (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration (3)
412. Heat Transfer (3)
413. Internal Combustion Engines (3)
417. Theory of Engineering Instruments (3)
418. Principles of Turbomachinery (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Design Analysis (3)
453. Bearing Design and Lubrication (3)
455. Automatic Control Systems (3)
457. Advanced Mechanisms (3)

503. Thermodynamic Process Analysis (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. Selected Topics in Mechanical Engineering (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Advanced Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions. Prerequisites: M.E. 412, Math. 451.

513. Advanced Heat Transfer—Convection and Radiation (3) Convection heat transfer in laminar and turbulent flow; two-phase heat transfer, transportation, film and ablation cooling, and radiation heat transfer. Prerequisite: M.E. 412.

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity

rules; theory of characteristics; two-dimensional supersonic flow; oblique shock waves.

520. Nonsteady Flow of Compressible Fluids (2-4) Method of characteristics; general flow problems; boundaries and discontinuities; interaction of discontinuities; wave diagram techniques and applications.

521. Electromagnetic and Thermodynamic Flow Systems (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

540. Simulation of Mechanical Engineering Phenomena (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) Sliding and rolling surface phenomena; hydrostatic, hydrodynamic, and magnetohydrodynamic lubrication theory; design and control of gas and fluid lubricated bearings.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. Advances in Control Systems Analyses (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods.

557. Mechanism Synthesis (3) Design and analysis of mechanisms for specific motion and energy requirements; intermittent mechanisms. Prerequisite: M.E. 457.

558. Fluid Control Systems (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY

Robert W. Lindsay, *Head of the Department*
121 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Lindsay, Muan, and Read; Associate Professors Healy, Hoke, and Ryba. Associate Members—Professors Bitler and Simkovich.

There is opportunity for a student to specialize, through both course work and

research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

To be prepared for the graduate program, the applicant should present a bachelor's degree in metallurgy or metallurgical engineering, or a satisfactory bachelor's degree in any other field which has included mathematics through ordinary differential equations; a year of basic physics; three courses in chemistry, including laboratory preferably, and covering inorganic chemistry and preferably physical chemistry; and three courses in metallurgy. Students who lack some of this background can be admitted but will be expected to make up their deficiency without receiving graduate credit.

METALLURGY (METAL)

401. Metallurgical Processes and Kinetics (3)
402. Electrometallurgy, Hydrometallurgy, and Corrosion (3)
404. Pyrometallurgy (3)
405-406. Metallography (3 each)
407. Metallurgical Engineering I (3)
408. Metallurgical Engineering II (3)
410. Metallurgical Investigations II (2)
412. Solid-State Metallurgy (3)
459. Metallurgical Applications for Engineers (3)

501. Metallurgical Problems (1-6 per term) Independent study of special problems in metallurgy.

502. Seminar in Metallurgy (1-6) Conferences, reading, reports, and special lectures.

508. Kinetics of Phase Transformations (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. Introductory Theoretical Physical Metallurgy (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. Prerequisites: Metal. 511, 513. *Mr. Read*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 513. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisites: Metal. 511, 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Chem. 452 or Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513. *Mr. Lindsay*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 511, 513.

525. Metal Finishing (3) Metallic coatings and their metallurgical properties; theories and problems of application, utilization, and evaluation. Prerequisite: Metal. 515. *Mr. Read*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Mineral Sciences.*

METEOROLOGY

Hans Neuberger, *Acting Head of the Department*
502A Deike Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Blackadar, Hosler, Neuberger, and Panofsky; Associate Professors Danielsen and Stephens. Associate Member—Associate Professor Duquet.

Candidates in meteorology may specialize in aerosol and cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, atmospheric optics and electricity, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

Requirements for admission include mathematics through differential equations and one year of college physics. Students with a strong background in mathematics, physics, or engineering may be admitted with deficiencies but must make up such deficiencies before they are admitted to candidacy for a degree.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
401. Physical Climatology for Teachers (3)
402. Biometeorology for Teachers (2)
403. Science Projects in Meteorology (1)
404. Physics of Weather Forecasting (3)
411. Introduction to Synoptic Meteorology (3)

418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
443. Physical Meteorology (3)
445. Hydrometeorology (3)
450. Applications of Statistics to Meteorology (3)
451. Thermodynamics of the Atmosphere (3)
452. Hydrodynamics of the Atmosphere (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
492. Meteorological Seminar (1-2)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Mineral Sciences.*

MICROBIOLOGY

Robert W. Stone, *Head of the Department*
206 Patterson Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Cone, Dunne, Gentry, Lindstrom, Ludwig, Stone, and Zimmerman; Associate Professor Casida. Associate Members—Associate Professor Heist; Assistant Professors Pootjes and Tershak.

Specialized areas of study include microbial physiology, soil microbiology, food and industrial microbiology, microbial genetics, immunology, bacteriophage, and virology. There is opportunity for cooperative research with other departments in animal disease, food technology, and waste disposal.

Prerequisites for admission are 20 credits in chemistry including quantitative analysis and organic chemistry, 6 in physics, and 8 in microbiology. Mathematics through calculus is recommended. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work.

MICROBIOLOGY (MICRB)

401. General Microbiology (4)
407. Problems in Microbiology (1-12)
410. Immunology and Serology (4)
411. Survey of Microbiology (1 per term)
412. The Bacterial Pathogens (4)
413. Soil Microbiology (3)
414. Food Microbiology (4)
416. Industrial Microbiology (4)
417. Epidemiology (2)
418. Bacterial Viruses (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Physiology of Bacteria (2-4) Composition, nutrition, and growth of microorganisms; influence of physical and chemical environment on metabolism.

509. Fermentation (2) Chemical activities of microorganisms; mechanisms of fermentative and oxidative metabolism.

512. Bacteriological Techniques (1-6) Practice in special laboratory techniques including manometry, tissue culture, and serology.

515. (V.Sc. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

MINERAL ECONOMICS

John D. Ridge, *Head of the Department*
101 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Ridge and Schanz. Associate Member—Associate Professor Gordon.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may

specialize in such areas as commodity analysis (fuels, metals, or nonmetals), resource economics (mineral policy or area studies), industrial economics (administration, market research, or financial analysis), or operations research and statistics (resource allocation, forecasting, or exploration programming).

The requirements for admission are 24 credits in chemistry, physics, mathematics, or statistics; 12 credits in the earth sciences; 9 credits in economics, mineral economics, commerce, business administration, or industrial management; and 6 credits in engineering subjects.

Students having a deficiency of 9 credits or fewer in this total of 51 may be admitted as degree students but will be required to make up such deficiencies without the credits being applicable toward the advanced degree.

In addition to the normal degree requirements of the Graduate School, students receiving the M.S. degree must have a minimum of 9 credits of economics (including courses used for admission) and must pass an oral defense of their thesis. Doctoral candidates must complete at least 15 credits of economics (including courses used for admission). The comprehensive examination for the doctorate includes written examinations on the major and minor fields in addition to the oral examination required by the Graduate School.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. The Metals and Their Ores (3)
484. Economics of Energy Resources (3)
486. Petroleum and Natural Gas Economics (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (3)

500. Advanced Principles of Mineral Economics (3-6) Mineral history, research methods in mineral economics, applications of economic theory, mineral policy problems, economics of mineral exploitation, selected readings.

501. Advanced Studies in Mineral Commodities (3-6) Case studies of economic or industrial problems, or both, of selected mineral commodities. Prerequisites: 3 credits in Mn.Ec. 500 and at least 3 credits in Mn.Ec. 453, 483, 484, or 486.

502. Technologic Influences (3-9) Relationship of technologic advancements to economic development of the mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

505. Problems in Mineral Economics (3-12) Individual research involving library, laboratory, or field work to develop solutions to selected techno-economic problems of the mineral industries. Prerequisite: Mn.Ec. 500.

590. Mineral Economics Seminar (1 per term) Preparation and presentation of papers on advanced problems. Required each term in residence.

MINERAL PREPARATION

Harold L. Lovell, *Acting Head of the Department*
110 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Spicer and Sun; Associate Professor Lovell. Associate Member—Associate Professor McLean.

Areas in which students may specialize include the fundamentals of gravity, electrical, and chemical methods of beneficiating natural mineral deposits. Graduate work may also be undertaken on the properties of specific minerals as they are related to beneficiation.

Graduates with a bachelor's degree in chemistry, physics, mathematics, mining, metallurgy, ceramics, fuel science, and chemical, mechanical, electrical, or civil engineering are eligible for admission. However, graduates in the above fields are required to take 6 credits in undergraduate courses in mineral preparation along with their graduate program.

MINERAL PREPARATION (MN PR)

401. Advanced Mineral Preparation Laboratory (1)
402. Mineral Preparation Seminar (1)
410. Coal Preparation (3)
420. Principles of Mineral Preparation Unit Operations (3)
421. Principles of Mineral Preparation Unit Operations (3)
425. Principles of Flotation (3)
426. Flotation Laboratory (1)
427. Modern Processes in Mineral Preparation (3)
430. Flowsheets of Mineral Preparation Plants (3)
457. Field Trip (1-2)

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 420. *Mr. Sun*

504. Mineral Preparation Research (1-6 per term) Research work on specific problems in mineral preparation. Prerequisite: Mn.Pr. 410 or 420.

505. Gravity Processes and Miscellaneous Methods of Mineral Preparation (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and dense-media processes of mineral concentration. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

506. Mineral Preparation Plant Design (3-10) Layout, design, and selection of equipment for specific mineral preparation plant projects. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

507. Chemical Processes of Mineral Preparation (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Mn.Pr. 420. *Mr. McLean*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineral preparation studies are listed under Mineral Sciences.*

MINERALOGY AND PETROLOGY

John C. Griffiths
Head of the Department of Geochemistry and Mineralogy
204 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Brindley, Burnham, Greig, Griffiths, Keith, Osborn, Roy, Vand, and Wright; Associate Professors Barnes, Dachille, Herzog, and Thornton; Mrs. Roy. Associate Members—Assistant Professors Hsu, Weber, and White.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, mineralogy, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography. Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

MINERALOGY (MIN)

400. (Cer.Sc. 400) Nonmetallic Crystal Chemistry (2) *Mr. Brindley*
402. Mineralogy and Petrology for Teachers (3)
413. Scientific Method Applied to the Earth Sciences (3) *Mr. Griffiths*
463. Optical Mineralogy (3) *Mr. Gibbon*
483. Petrology (3) *Mr. Thornton*
484. Petrology (2) *Mr. Griffiths*

500. Optical Crystallography of Minerals (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Wright*

501. Petrology (3-6) Miscroscopic study of rocks, emphasizing classification and genetic relationships. *Messrs. Thornton and Griffiths*

502. Mineralogical Problems (3) Original study of some limited mineralogical or petrological problems.

505. Mineralogy Seminar (1-2) Reading, presentation, and discussion of literature dealing with various phases of theoretical mineralogy. Topics are selected to meet the interests of the majority of the students.

*510. Metamorphic Petrology (2-6) Detailed review of chemical, mineralogical and structural changes that take place during metamorphism. Prerequisites: Min 483, 484.

511. Sedimentary Petrology (3-4) Composition, texture, structure, mass properties of sediments; dynamic processes in complex natural systems; sedimentary stages: weathering, erosion, transport, deposition, lithification. Prerequisites: Min 483, 484. Concurrent: Min. 513.

513. Methods of Analysis of Sediments (3) Principles and practices used in analyzing sedimentary rocks for size, shape, and accessory (heavy) minerals. Concurrent: Min. 511. *Mr. Griffiths*

514. Applied Sedimentology (3) Design and control in analysis of sedimentary rocks; application of these techniques to industrial problems. *Mr. Griffiths*

520. Study of Accessory Minerals (2-4) Detailed study of accessory (heavy) minerals; their significance in problems of provenance, petrogenesis, mineral stratigraphy, and paleogeography. Prerequisites: Min. 511, 513, 514. *Mr. Griffiths*

* Credits to be arranged, 2-4 per term.

24. Introduction to Sedimentation (3) Prerequisites: Min. 483, 484.

25. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Mr. Thornton*

26. Statistical Problems in Sedimentary Geology (3) Application of experimental design, sampling procedures, multiple regression and discriminant analysis in solving problems in sedimentary petrography. Prerequisites: Min. 514; Math. 410 or Agro. 545. *Mr. Griffiths*

27. Igneous and Metamorphic Mineralogy (3) Structural and compositional variations of minerals in igneous and metamorphic rocks.

29. Radioactivity in Rocks (1-2) Distribution, mineralogy, and petrology of the radioactive elements. *Mr. Wright*

30. (Cer.Sc. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Hsu*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Mineral Sciences.*

MINING ENGINEERING

Robert Stefanko, *Head of the Department of Mining*
118 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Kochanowsky and Stefanko. Associate Members—Associate Professor Singh; Assistant Professor Manula.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting), mechanization and mine plant (unit operations, materials handling, continuous mining, power supply), development and exploitation methods (mine planning and layout, design of systems), mine management, production engineering and operations research (time study, standards, job rating, operations analysis), environmental control (gas and dust technology, ventilation, air conditioning, hygiene, illumination, safety), and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation).

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic, related courses outside the department may be approved as part of the major.

MINING (MNG)

102. Mine Plant Design (3)
110. Mining Engineering Analysis (3)
111. Mine Systems Engineering (3)
122. Mine Ventilation and Air Conditioning (3)
131. Rock Mechanics (3)
451-452. Advanced Mining Engineering I and II (1 each)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management Prerequisite: Mng. 411.

515. Mine Systems Simulation (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Mng. 411, Cmp.Sc. 401.

525. Dust Technology (3) Physical and chemical properties of dusts; airborne dust determinations and analysis; dust control applicable to mills and mines. Prerequisite: Mng. 422.

531. Rheological and Strength Characteristics of Rocks (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.

532. Special Topics in Rock Mechanics (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.

533. Post-Yield Mechanics of Rock (3) Theory of inelastic, time-independent rock behavior; selected applications to drilling, blasting, mine opening, pit slopes and ore passes. Prerequisite: Mng. 431.

541. Theory of Rock Penetration (3) Behavior of rock under dynamic load intended to penetrate; basic energy relations; application of theory to drilling and other penetration. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic load intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. Rock Mechanics Instrumentation (3) Strain gage circuitry, transducers electro-hydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Graduate Mining Seminar (1 per term) Preparation and presentation of formal papers on problems of an advanced nature in mining engineering. Required once during each year of residence.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mining studies are listed under Mineral Siences.*

MUSIC

Robert W. Baisley, *Head of the Department*
232 Music Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members—Professors Henninger and Taylor; Assistant Professor Brinsmaid. Associate Members—Professor Baisley; Assistant Professor Case.

In his graduate program a student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, music literature, and creative music.

Admission requires completion of a recognized undergraduate music major.

A thesis is required of all M.A. candidates in this major.

MUSIC (MUSIC)

407. Piano Literature (3)
410. Music of the 20th Century (3)
411. A Chronological Study of String Literature (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
*†429. Singer's Style and Interpretation (3) Fee $80.
433. The Singing Voice (3)
455. Form and Analysis (3)
456. Counterpoint (3)
457. Composition (3)
459. Modern Instrumental Arranging (3)
466. Advanced Conducting (3)

*‡501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

*‡503. Advanced Stringed Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*‡511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*‡531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on 20th century practices with attention to traditional idioms that serve as foundation.

557. Symphonic Structure (3) Survey of the evolution and application of the forms used in symphony, sonata, concerto, string quartet, and related works. Prerequisite: Music 369.

*‡558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

563. Free Arranging (3) Correct procedure in arranging for vocal and instrumental ensembles; practical exercises in quartets, glee clubs, and choruses; small instrumental groups, band, and orchestra.

567. The Literature of the Orchestra (3) The suite, symphony, tone poem, and overture from the point of view of appreciation, form, and orchestration.

599. Music Seminar (1-3) Seminar in the history, art, and science of music, with readings, discussion, and performance.

* Course may be scheduled only by conference with the head of the department.
† May be repeated for a total of 27 credits.
‡ May be repeated for a total of 18 credits.

MUSIC EDUCATION

FRANCES M. ANDREWS, *Head of the Department*
264 Chambers Building

Degrees Conferred: D.Ed., M.Ed.
Graduate Faculty: Senior Members—Professors Andrews and Dunlop. Associate Members—Professor Campbell; Assistant Professors Deihl and Fosse.

Graduate programs in music education offer work in the various areas of public school music, including general, instrumental, and vocal/choral music on the elementary and secondary levels; preparation is also offered for supervisory or administrative positions, college teaching, and research. It is possible to include work from a number of these areas in the M.Ed. or D.Ed. programs.

For admission to the D.Ed. program, a minimum of two years of teaching experience is required.

Completion of a recognized music education major, or program leading to certification, is a prerequisite for admission to the M.Ed. or D.Ed. programs.

MUSIC EDUCATION (MU ED)

446. THE ELEMENTARY MUSIC SPECIALIST (3)
462. PEDAGOGY OF THEORY (3)
468. THE TEACHING OF PIANO (3)
469. BAND AND ORCHESTRA TECHNIQUE (3)
470. CHORAL TECHNIQUE (3)
471. TEACHING MARCHING BAND (2)
472. WIND INSTRUMENT MATERIALS (2)
475. OBJECTIVES AND PROBLEMS IN ELEMENTARY MUSIC EDUCATION (3)
480. CHORAL PROGRAM IN THE SECONDARY SCHOOL (3)
*487. CHILDREN'S SONGS AND RECORDS (3)

500. MUSIC EDUCATION SEMINAR (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

569. PRESENT-DAY TRENDS IN INSTRUMENTAL MUSIC (3) New methods and materials for band, orchestra, and ensembles.

572. INSTRUMENTAL PEDAGOGY (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

574. PRESENT-DAY TRENDS IN MUSIC EDUCATION (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. THE JUNIOR HIGH SCHOOL MUSIC CURRICULUM (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. MUSIC SUPERVISION (3) Current educational procedures in training music supervisors.

581. CONTEMPORARY MUSIC EDUCATION (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

* Credit not allowed for students majoring in music or music education.

582. Theory and Projects in Musical Learning (3-6) Experimentation and self-instructional techniques involved in musical learning projects. Prerequisite: Ed.Psy. 435.

594. Pedagogy of Ear Training (3) Materials and methods for training the listener to grasp, understand, and write what is heard from melody to four-part harmony. Prerequisite: 12 credits in ear training and/or harmony.

599. Internship in Music Performance Techniques (3-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.

NUCLEAR ENGINEERING

Nunzio J. Palladino, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.
Graduate Faculty: Senior Members—Professors Foderaro, Kline, and Palladino; Associate Professors Diethorn, Jacobs, and Remick. Associate Member—Associate Professor D'Ardenne.

A student may specialize in reactor physics, neutron and radiation transport phenomena, thermal and mechanical design of reactors, supervision and utilization of research reactors, nuclear materials, or reactor instrumentation and control. Admission requires a bachelor's degree in engineering or in the physical sciences. Students who have not had appropriate undergraduate courses in modern physics and differential equations will be required to schedule them.

NUCLEAR ENGINEERING (NUC E)

401. Introduction to Nuclear Engineering (3)
410-411. Nuclear Engineering (3 each)
420. Radiological Safety (2)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 521.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 100.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

550. Special Topics in Nuclear Engineering (1-12) Theoretical studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 44, Phys. 406.

PETROLEUM AND NATURAL GAS ENGINEERING

C. Drew Stahl
Head of the Department of Petroleum and Natural Gas
26 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Nielsen, Slobod, and Stahl; Associate Professors Bissey and Burcik.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

Students who expect to enter graduate study in this field with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission.

Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

PETROLEUM AND NATURAL GAS (P N G)

410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
431. Drilling Fluids (2)
450. Drilling Design and Production Engineering (3)

475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)
493. Engineering Evaluation of Oil and Gas Properties (3)
495. Formation Evaluation (3)

510. Flow of Homogeneous Fluids Through Porous Media (3) Applications of vectors, separation of variables, conformal mapping, Laplace transform to describe steady and unsteady state flow in porous media.

511. Material Transfer in Porous Media (3) Diffusion and convective mixing in porous media; solution of the partial differential equations involved; difference methods; mathematical model, viscous instabilities.

512. Reservoir Engineering (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

517. Case Studies of Secondary Recovery (1-3) Interpretation and critical analysis of production and injection characteristics of typical water flood operations. Prerequisite: P.N.G. 515 or 485.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

525. Special Topics in Petroleum Engineering (2-6)

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycles; current developments. Prerequisite: P.N.G. 481.

*535. Seminar (1-3)

540. Special Studies in Petroleum Engineering (1-3) Supervised short study performed in the field, library, or laboratory covering any approved topic related to petroleum engineering.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Mineral Sciences.*

PHILOSOPHY

John M. Anderson, *Head of the Department*
420 Boucke Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Senior Members—Professors Anderson, Bugbee, Finch, Freund, Johnstone, Mourant, and Rosen; Associate Professors Gotshalk and Lingis. Associate Members—Associate Professors Price and Tsugawa; Assistant Professors Allison and Whittier.

* Credits to be arranged, 1 per term.

A thorough grounding in the history of philosophy is required of all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics and social philosophy, logic), in movements of thought (such as rationalism, empiricism, idealism, phenomenology, existentialism), or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics. Undergraduate preparation to the extent of a strong minor is advisable.

The department may waive the requirement of a thesis for an M.A. candidate.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
410. Studies in Greek Philosophy (3-6)
411. Studies in Modern Philosophy (3-6)
412. Studies in Contemporary Philosophy (3)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)
417. Nineteenth Century Philosophy (3)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Classics of Scientific Method (3)
422. Philosophical Logic (3)
426. Metaphysics (3)
427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (1-9)
435. Religion and Science (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

507. Seminar in Medieval Philosophy (3-6) Study of one or more important men or movements in medieval philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the 19th century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in 20th century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in 19th Century Philosophy (3-6) Study of a philosopher or philosophical movement of the 19th century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (3-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550-551. (Math. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Phil. 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions, recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Phil. 428.

557. (Math. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisites: Phil. 554, 556.

PHYSICAL EDUCATION

Benjamin H. Massey
Associate Dean of the College of Health and Physical Education
238A Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Buskirk, Conger, Coombs, Gross, Harnett, and Massey. Associate Members—Associate Professors Magnusson, Nelson, and van der Smissen; Assistant Professor Kollias.

Areas of specialization include (1) physiology of exercise (physical conditioning, physical fitness, and performance stress); (2) kinesiology (applied anatomy and biomechanics); (3) measurement and test construction; (4) cultural bases of physical education and sport (history, philosophy, and sociological foundations); (5) motor learning; (6) organization and administration (methods and materials, curriculum construction, intramurals, and interscholastics); and (7) recreation and parks.

Admission to the M.S. program requires a major in physical education or its equivalent in comparable course work. Especially desirable is course work in mathematics plus a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended areas of specialization. Admission to the M.Ed. program requires a minimum of 18 credits in health and physical education plus 18 credits in education and educational psychology combined, including practice teaching. A year or more of field experience is recommended.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable

performance on the Aptitude Test of the Graduate Record Examination or other specified tests. A student who has earned a master's degree in recreation and parks and meets the above requirements may enter a doctoral program in physical education with specialization in recreation and parks.

See also "Recreation and Parks."

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)

501. Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

PHYSICAL EDUCATION (PH ED)

400. Adaptive Physical Education (3)
452. Analysis of Physical Education Activities for the Elementary School (3)
455. Scientific Method in Health and Physical Education (3)
460. Methods and Principles of Athletic Coaching (3)
480. Advanced Anatomy and Physiology, Applied (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)

500. Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

530. Research Techniques in Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 490.

531. Research in Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

536. Scientific Methods in Athletic Coaching (3) Unusual techniques in athletic coaching which are not commonly recognized and used; advanced skills and strategy in coaching major sports. Prerequisite: Ph.Ed. 460.

550. Seminar in Health and Physical Education and Recreation Education (1-6)

555. Relationships of Physical Education to the Exact Sciences (3)

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education into the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

581. Problems in Body Mechanics (3) Certain aspects of human motion and body segmental alignment; analysis of human gait, and the dynamic adaptation of the spine, thorax, and pelvis to external physical forces. Prerequisites: Hl.Ed. 244, Ph.Ed. 400.

582. Advanced Kinesiology (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments. Prerequisite: Hl.Ed. 244.

585. (Phsio. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Phsio. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Phsio. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.

595. Philosophy of Health and Physical Education and Recreation Education (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICAL SCIENCE

Henry W. Knerr
Chairman of the Committee on Physical Science
101 Willard Building

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, includes at least 24 credits in physical science chosen from chemistry, earth sciences, mathematics, and physics and a minor of at least 6 credits in education. A candidate is required to earn at least 15 credits in chemistry and physics with a minimum of 6 in each, and at least 3 credits each in earth sciences and mathematics. The completion of a satisfactory term paper and a course in integral calculus is also required.

For admission to the M.Ed. program a student is expected to have completed at least one year each in college chemistry and college physics, mathematics through trigonometry, and 18 credits in education and related psychology. For admission to the D.Ed. program a course in integral calculus is also required.

The D.Ed. program requires a minimum of 60 credits in physical science of which 24 may be in courses designed specifically for teachers. At least 12 credits each in chemistry and physics must be selected from standard courses at the 400 and 500 level. A minimum of 15 credits each is required in professional education and thesis research. The thesis may be based on an experimental study in chemistry or physics or on the study of a problem in the teaching of physical science.

See also "Earth Sciences," "Chemistry," "Mathematics," and "Physics."

PHYSICS

David H. Rank, *Head of the Department*
101 Osmond Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Bleuler, Brickwedde, Frankl, Gibbons, Knerr, McCubbin, Müller, Polo, Pratt, Rank, Schilling, Skudrzyk, Webb, and Wiggins; Associate Professors Atwater, Cutler, Kazes, Kendall, McKelvey, Strother, Weber, and Whitfield. Associate Members—Associate Professors Feuchtwang and Schumacher; Assistant Professors Eastman, Fleming, Freed, Graetzer, Herman, McCammon, and Thwaites.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, laser physics, solid state, field emission, acoustics, high-pressure physics, low-temperature physics, nuclear physics, physics of high polymers, electron spin resonance of solids, and various phases of theoretical physics.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including Phys. 400 and 458 and approved laboratory work such as Phys. 470; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
411. Theoretical Mechanics (3)
412. Introduction to Solid State Physics (3)
420. Intermediate Heat (3)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
436. Optics for Teachers (3)
437. Heat, Wave Motion, and Sound for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
441. Demonstration Experiments for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)

507. Thermodynamics (3) Classical thermodynamics and thermodynamics of irreversible processes. Prerequisites: Phys. 420, Math. 417.

509. Physics Seminar (1-3 per term) Topics from current research.

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 507, 561.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle; canonical transformation; Lagrange and Poisson brackets; Hamilton-Jacobi equations; classical theory of field. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and visco-elastic media. Prerequisite: Phys. 530.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

560. Research Problems (1-10) Introduction to research through individual assignments.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

575. Special Topics (1-3 per term) Theoretical studies in any field of modern physics with or without associated experimental work. Prerequisite: Phys. 456.

PHYSIOLOGY

Richard D. Schein
Chairman of the Committee on Physiology
211 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

This is an interdisciplinary program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and

advanced training in a specialized area.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal science, biochemistry, biophysics, and zoology, and the Human Performance Research Laboratory. The instructional staff is composed of the program committee as well as faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cellular and subcellular physiology, environmental physiology, endocrinology, applied physiology (human performance), physiology of nutrition and metabolism, or comparative physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements.

The following courses are available for physiology majors, and their descriptions may be found under the offerings of several departments: Anthy. 401; A.Ntr. 401, 402; Bioch. 401, 402, 417, 436, 437, 501, 517, 519, 520, 521; Bphys. 473, 474, 475, 580; D.Sc. 427, 431, 512, 515, 521; F.N. 452, 457, 459, 552, 557; Micrb. 401, 508; Psy. 402, 403, 503; V.Sc. 400; and Zool. 401, 471, 541, 583.

PHYSIOLOGY (PHSIO)

571. (Zool. 571) Animal Physiology (2) Physiology and fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Zool. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Zool. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates and special senses. Prerequisite: 3 credits in physiology.

574. (Zool. 574) Animal Physiology Laboratory (3) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisites: Phsio. 571, 572. Prerequisite or concurrent: Phsio. 573.

585. (Ph.Ed. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Ph.Ed. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Ph.Ed. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Phsio. 585.

PLANT PATHOLOGY

James Tammen, *Head of the Department*
111 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Boyle, Kneebone, Lewis, Mills, Tammen, and Wernham; Associate Professors Bloom and Merrill; Assistant Professor Wood. Associate Members—Professor Hyre; Associate Professor Schisler; Assistant Professor Wuest.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension or industry through advanced studies on the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology, and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. It is strongly recommended, but not required, that an applicant have 3-6 credits in a foreign language. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

PLANT PATHOLOGY (P PATH)

408.	Plant Pathological Techniques (3)	*Mr. Bloom*
410.	Intermediate Plant Pathology (1)	*Mr. Wuest*
411.	Diseases of Ornamental and Floricultural Plants (2)	*Mr. Nelson*
412.	Advanced Forest Pathology (2)	*Mr. Merrill*
413.	Diseases of Field Crops (2)	*Mr. Lukezic*
414.	Diseases of Fruit and Vegetable Crops (2)	*Messrs. Bloom and Boyle*
429.	Phytonematology (3)	*Mr. Bloom*

401. Clinical Plant Pathology (3) Advanced course in diagnostic techniques to acquaint the students with specialized procedures for field and laboratory identification of plant diseases. Prerequisites: P.Path. 10, 408, Bot. 419. Summer term, odd years.

410. Advanced Plant Pathology (3) Principles of plant disease development; emphasis on physiology of suscept-pathogen interactions and on development of epiphytotics. Prerequisites: P.Path. 410, Bot. 419. Winter term, odd years.

415. Disease Resistance in Plants (2-4) Stability of resistance, selection of resistant material, economics of control, special problems. Prerequisites: Bot. 22 or 33, P.Path. 10. Fall term, odd years. *Mr. Wernham*

418. Special Problems (1-12) The prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Virus Diseases of Plants (3) Nature, symptomatology, transmission, and control of virus diseases of plants. Fall term, even years. *Mr. Boyle*

520. Plant Pathogenic Bacteria (3) Bacteria causing plant diseases; methods of identification, inoculation, and control. Spring term, odd years. *Mr. Kneebone*

530. Plant Disease Control (3) Methods, and laboratory and field testing of materials used in plant disease control. Spring term, even years. *Mr. Cole*

531. Plant Pathology Seminar (1 per term) Selected topics of current research, history, and contemporary trends in plant pathology. *Mr. Tammen*

POLITICAL SCIENCE

Bernard C. Hennessy, *Head of the Department*
129 Sparks Building

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Senior Members—Professors Aspaturian, Atwater, Ferguson, Hennessy, Masters, McGeary, Monat, Mowitz, and Silva; Associate Professor Albinski. Associate Members—Assistant Professors Kochanek, Leduc, and Pettit.

Students may specialize in American government, public administration, political theory, international relations, or comparative government.

Applicants for admission will be expected to have at least 12 credits in political science or its equivalent. In exceptional cases students may be permitted to make up deficiencies after beginning their graduate programs.

The department may waive the requirement of a thesis for M.A. candidates in this major.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Messrs. Keynes, Masters, and Petti*
403. The Legislative Process (3) *Messrs. Masters and Petti*
411. American Political Theory (3) *Messrs. Eisenach and Ricc*
412. International Organization: Economic and Social Welfare Functions (3) *Mr. Atwate*
413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian and Atwate*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturia*
415. International Organization: Political and Security Functions (3-6) *Messrs. Aspaturian and Atwate*
416. International Law (3)
417. American Local Government and Administration (3) *Mr. Ledu*
419. Bureaucracy and Public Policy (3) *Mr. Mona*
421. Modern Political Theory (3)
426. Political Parties (3) *Miss Silv*
427. Political Opinion and Propaganda (3) *Miss Silva and Mr. Petti*
431. Ancient and Medieval Political Theories (3) *Mr. Ricc*
433. The Law of Labor-Management Relations (3) *Mr. Boya*
442. American Foreign Policy (3) *Mr. Atwate*
444. Government Regulations (3) *Mr. Ferguso*
445. Administrative Law (3) *Mr. Boya*
447. Constitutional Law: The Federal System (3) *Miss Silv*
448. Constitutional Law: Government and the Individual (3) *Mr. Boya*

449. Anglo-American Legal Systems (3) *Mr. Eisenach*
450. Canadian and Australian Politics and Foreign Policies (3) *Mr. Albinski*
451. Comparative Political Analysis (3) *Mr. Albinski*
453. Politics and Institutions of Developing Areas (3-6) *Mr. LaPorte*
456. Politics and Institutions of Latin-American Nations (3) *Mr. DeProspo*
457. International Politics of Latin America (3-6) *Mr. DeProspo*
458. Governments and Foreign Policies of the Far East (3-6) *Mr. Kochanek*
459. Government, Politics, and International Relations of South Asia (3) *Mr. Kochanek*

499. Foreign Study in Government (2-6)

500. Political Power (3-6) Subject to be announced.

505. Executive Power (3-6) *Miss Silva, Messrs. Ferguson and Monat*

509. Scope and Method of Political Science (3-6) *Mr. Pettit*

512. Comparative Political Systems (3-9) *Messrs. Albinski and Kochanek*

513. Seminar in Comparative Political Parties (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Mr. Albinski*

515. International Politics (3-6)

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

518. Latin-American Politics (3-6) Forces which shape the quest for power and the process by which public policies are determined.

521. Modern Democratic Political Theory (3-6)

522. Comparative Foreign Policies (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Mr. Aspaturian*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

527. Politics and Legislative Behavior (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Mr. Masters*

528. Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies. *Mr. Masters*

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form. *Messrs. Ferguson and Monat*

530. Public Law (3-6) The nature of law and its role in modern society.

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Mr. Aspaturian*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought.

571. Theory of Public Administration (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Mowitz*

572. International Development Administration (3-6) The execution of for eign policies through national and international public and private organizations.

573. Comparative Public Administration (3-6) Administrative systems of se lected nations on a functional basis; relationship between culture, economic an social systems, and public administration.

574. Seminar in the Administration of United States Foreign Affairs (3 Effect of cross-cultural operations on the normal process of administration of Unite States foreign affairs.

575. Government Manpower Management (3) Government personnel system current trends and problems; essentials of recruitment, classification and pay, ra ings, supervision, training, and discipline.

576. Government Fiscal Decision-Making (3) The role of the executive i fiscal planning; budget preparation; expenditure control; tax assessment and collec tion; investment of public funds. *Mr. Mone*

577. Organization and Systems Management (3) Principles of government or ganization; management surveys; work measurement; methods of achieving eff ciency and economy. *Mr. Mowit*

578. Public Planning and Development Administration in the United State (3) Public planning agencies and their functions; essentials of effective plannin and zoning; current trends and problems. *Mr. Ledu*

580. Internship in Public Administration (6)

POULTRY SCIENCE

Kenneth Goodwin, *Head of the Department*
103 Weaver Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Bressler, Hale, and Mueller. Asso ciate Members—Professor Buss; Associate Professor MacNeil.

The department offer two types of graduate programs. Students interested i genetics or physiology may participate in these interdisciplinary programs with thes research in the Department of Poultry Science. (See "Genetics" and "Physiology for admission requirements.)

The programs in behavior, food technology, management, and nutrition consist of major in poultry science and a minor in one or more basic science departments. Ad mission requirements include 30 credits in biology, chemistry, mathematics, an physics.

POULTRY SCIENCE (PTY SC)

401. (Psy. 401, Zool. 401) Animal Behavior (3) *Mr. Ha*
402. Special Topics (3-12)
405. Poultry Production Technology (3)

502. Advanced Poultry Nutrition (2-4) *Mr. Murpi*

503. Advanced Poultry Farm Management (2-4) *Mr. Bressl*

504. Advanced Market Poultry and Eggs (2-4) Prerequisites: Fd.T. 202 and 2 additional credits in poultry science. *Messrs. Mueller and MacNeil*

505. Research in Poultry Science (1-10 per term) Prerequisite: 9 credits in poultry science.

506. Seminar in Poultry Science (1-6)

582. (Psy. 582, Zool. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale and Schein*

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

PSYCHOLOGY

Dale B. Harris, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.S.

Graduate Faculty: Senior Members—Professors Bernreuter, Carpenter, Cofer, Hale, Guest, Guthrie, Hall, Harris, Leibowitz, Lundy, Mitzel, Palermo, Rabinowitz, Smith, VanOrmer, and Warren; Associate Professors Gorlow, Hoffman, Schipper, and Theaos; Assistant Professor Seibel. Associate Members—Associate Professors Dubin, Piers, and Whaley; Assistant Professors Freeman, Galbraith, and Stern.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, measurement and statistics, social and personality, developmental, clinical, industrial and business, engineering and human factors.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computer Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a junior-senior scholastic average of B, a minimum of 12 credits in psychology, and a satisfactory graduate student rating on the Miller Analogies Test. Applicants with a master's degree will have their admission evaluated with emphasis on the quality of their graduate program.

PSYCHOLOGY (PSY)

401. (Pty.Sc. 401, Zool. 401) Animal Behavior (3) *Mr. Hale*
402. Sensation and Perception (3) *Mr. Freeman*
403. Introductory Physiological Psychology (3) *Mr. Warren*
404. Learning and Motivation (3) *Mr. Hall*
405. The Experimental Psychology of Visual Perception (3) *Mr. Leibowitz*
406. Experimental Social Psychology (3)
408. Comparative Psychology (2-4) *Mr. Warren*
410. History of Psychology (3) *Mr. Leibowitz*
412. Abnormal Psychology (3)
413. Biographical Psychology (3) *Mr. Harris*
415. Intermediate Experimental Design (3)
417. Social Psychology (2-3)

418. Measurement of Personality (3)
419. Guidance and Education in Sexual and Marital Adjustment (3)
422. Psychological Methods of Measuring the Reactions of the Public (3) *Mr. Gues*
425. Psychology of the Elementary School Child (2-3) *Mr. Whale*
426. Adolescence (2-3) *Mr. Harri*
427. Psychological Principles in Advertising (3) *Mr. Gues*
428. Opinion Research Laboratory (3) *Mr. Gues*
430. Verbal Behavior and Verbal Learning (3) *Mr. Cofe*
431. Industrial Psychology (3) *Mr. Smith*
432. Introductory Engineering Psychology (3) *Mr. Schippe*
433. Psychology of Occupational Behavior (2) *Mr. Dubi*
436. Mental Hygiene in Schools (3)
437. Psychology of Adjustment (3) *Mr. Gorlou*
438. Theory of Personality (3) *Mr. Gorlou*
440. Psychology Projects (1-6)
441. Industrial Motivation and Morale (3) *Mr. Gues*
445. (C.D.F.R. 445) Development Throughout Adulthood (3) *Mr. Britto*
450. (Ed.Psy. 450) Principles of Measurement (3)
474. Psychology of Exceptional Children (3) *Miss Pier*
482. Introduction to Clinical Psychology (3) *Mr. Galbraith*

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

501. Advanced Psychology (3) Comprehensive study of general psychology. Pre requisite: 9 credits in psychology.

503. Physiological Psychology (2-6) Correlations between structure and func tion of nervous system and human consciousness; laws and theories in fields o sensation, attention, association, affection, and thought. Prerequisite: 9 credits i psychology. *Mr. Warre*

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psy chology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 o Ed.Psy. 421.

511. Seminar in Contemporary American Psychology (2-3) Current system or schools of psychology with comparative study and critical analysis; points o view as presented by recognized leaders. Prerequisite: 9 credits in psychology.

515. Advanced Statistics in Psychology and Education (3) Correlation theor and methods, discriminant function, and factor analysis; applications to menta test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

518. Projects in Experimental Psychology (2-4) Individual experimental pro ects; seminars on experimental design and instrumentation.

527. Statistical Inference and Experimental Design (3) Probability theor sampling distributions, analysis of variance and covariance, analysis of trend, nor parametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

528. Opinion Research Administration (3-6) Practicum in planning, develo ment of techniques, and administration of the sample survey. Prerequisites: Ps 15, 21, 422. *Mr. Gue*

529. (C.D.F.R. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisite: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

535. Human Development (2-3) Psychological phases of human development throughout the life span; implications for school, community, and home. Prerequisite: 9 credits in psychology.

536. (C.D.F.R. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

537. Seminar in Industrial Psychology (3) Prerequisite: Psy. 431. *Mr. Smith*

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421. *Mr. Smith*

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives. *Mr. Hall*

540. Seminar in Clinical Problems (1-6) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality and relevant research with emphasis upon normal processes. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (3)

549. (C.D.F.R. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

555. Theory and Practicum in Clinical Assessment (3) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

556. Theory and Practicum in Clinical Assessment of Pathological Syndromes (3) Current research and theoretical issues in the clinical assessment of pathological syndromes; includes practicum. Prerequisite: Psy. 555.

558. Clinical Child Psychology (3) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 425, 426, 555, 561. *Miss Piers*

559. The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment; includes principles of school psychology. Prerequisites: Psy. 425, 426, 555.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-6) Practical experience in the Psychology Clinic in advanced nondirective therapy techniques; staff meetings; case conferences.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Pty.Sc. 582, Zool. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.
Messrs. Hale, Schein, and Warren

590. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION

Robert J. Mowitz
Director of the Institute of Public Administration
302 Engineering E

Degree Conferred: M.P.A.
Graduate Faculty: Senior Members—Professors Ferguson, Masters, Monat, Mowitz, and Silva. Associate Members—Assistant Professors Leduc and Pettit.

All candidates take a core program and may concentrate through electives in one of the following areas: general public administration, municipal management and public planning, or international development administration.

Candidates for admission ordinarily will have at least 12 hours of undergraduate credit in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

RECREATION AND PARKS

Benjamin H. Massey
Associate Dean of the College of Health and Physical Education
238A Recreation Building

Degrees Conferred: M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Coombs, Gross, and Massey. Associate Members—Associate Professors Nelson and van der Smissen; Assistant Professor Lewis.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Areas of specialization include (1) recreation and park administration, including outdoor recreation planning, (2) recreation program supervision and administration, including recreation for special groups, (3) camping, outdoor education, and outdoor interpretive services, and (4) professional education.

The master's degree may be earned in the major field of recreation and parks. At the doctoral level, attention is called to the programs available in the physical education major.

For admission to the graduate program, a bachelor's or master's degree is required in recreation, park administration, or in a related field; e.g., forestry, landscape architecture, sociology, psychology, physical education, education, fine arts.

RECREATION AND PARKS (RC PK)

420. Outdoor Recreation (3)
430. Outdoor Education (3)
456. Recreation Program Organization (3)
461. Community Recreation (3)
465. Administration of Recreation and Parks (3)
470. Metropolitan Park Management (3)
475. Recreation for Special Groups (3)

530. Camp Administration (3) Camp site development; staff selection, training, and supervision; development of objectives and program planning; values inherent in outdoor and camping education. Prerequisite: Rc.Pk. 430.

560. Administrative Problems of Recreation (3) Administrative problems in park and recreation departments; departmental organization, finance, personnel, facilities, program, and public relations. Prerequisite: Rc.Pk. 465.

REGIONAL PLANNING

Frank B. Burggraf, Jr.
Chairman of the Committee on Regional Planning
213 Sackett Building

Degree Conferred: M.R.P.

This program emphasizes the training of technically competent planners and the development of their awareness of the importance of the social, political, economic, and cultural goals of the citizens in a region. Requirements for admission include at least one course each in sociology or political science; physical geography, geology, or soils; and engineering or architectural graphics, plus 6 credits in mathematics.

REGIONAL PLANNING (R PL)

400-401. Principles of Regional Planning (3 each)
410. Planning Programs (3)
420. Theory and Methodology of Regional Planning (3)

510. Planning Techniques and Analysis I (3) Regional socio-economic structure, problems, and factors in planning; data collection, analysis, and implications.

520. Planning Techniques and Analysis II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. Planning Techniques and Analysis III (3) Physical, aesthetic, and cultural design aspects of planning. Cultural value judgments and environmental design.

600. Thesis.

610. Thesis.

RURAL SOCIOLOGY

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.
Graduate Faculty: Senior Members—Professors Bonser, Brown, and John; Associate Professors Bealer and Copp. Associate Members—Associate Professor Fliegel; Assistant Professors King and Willits.

In all programs emphasis is on a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, there are available certain areas of special interest and research: consumer behavior; instigated social change; community structure; human resource development; migration; adolescent behavior; the culture of poverty; the ecology of rurality in industrialized, urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at this University during the early part of his master's program.

RURAL SOCIOLOGY (R SOC)

401. Special Topics in Rural Sociology (1-6)
402. Consumer Behavior and the Agricultural Industry (3)
444. Rural Life in an Industrial Society (3) *Mr. Copp*
452. Rural Organization (3) *Mr. Copp*
459. Rural Social Psychology (3) *Mrs. Willits*

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology. *Mr. Bealer*

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems. *Mr. Bealer*

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452.

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior.

514. Values in Rural Society (2) Values as dynamic forces in rural society. *Mr. Bealer*

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system with emphasis on techniques of organization and program development. *Mr. Brown*

516. Change in Rural Society (2) Social change in rural society emphasizing prediction and control of the change process. *Mr. Fliegel*

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING

Benjamin A. Whisler
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.
Graduate Faculty: Senior Members—Professors Kountz, Nesbitt, and Whisler. Associate Member—Assistant Professor McDonnell.

The entering student should be a graduate in sanitary engineering from an accredited college of engineering, but a graduate in civil engineering may obtain the M.S. in sanitary engineering by taking a limited amount of extra undergraduate work in subjects appropriate to the sanitary engineering field. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 471, 472, 571, 572, 573, 574, 575, 576, 577, and 578. Appropriate courses offered by other departments include: Ag. 400; Bioch. 425, 436; Chem. 405; Cmp.Sc. 402; Geol. 452; Meteo. 445; Micrb. 401, 414; Nuc.E. 420; Pl.Sc. 419; and Zool. 410.

SCHOOL PSYCHOLOGY

Joseph L. French
Chairman of the Committee on School Psychology
119 Education and Psychology Center, Building II

Degrees Conferred: D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Carriker, French, Harris, Lundy, and Rabinowitz; Associate Professors Hottel, Lathrop, and Thevaos. Associate Member—Associate Professor Frick.

This interdisciplinary program based on courses in psychology, educational psychology, special education, and related fields is designed to produce dually oriented

professionals who are well prepared in both psychology and education. The objective is to develop a psychologist who is interested in and knowledgeable about schools. The school psychologist must utilize his professional skills and his knowledge about children and youth to make contributions which are meaningful to and utilized by teachers. The development of competencies needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Other areas of study related to school psychology, such as clinical psychology, general educational psychology, counselor education, and child development, are found in other departments of the University.

Practicum facilities include the speech pathology and audiology out-patient service, the Reading Center, the Psychology Clinic, and the Demonstration School for mentally retarded children. Facilities for work with children are available through other departments also.

An undergraduate major in psychology or in education of exceptional children is expected of applicants, but students with less than 15 credits in psychology may be admitted with limited deficiencies to be made up concurrently with their graduate studies. Requirements for admission include a minimum junior-senior scholastic average of B and a satisfactory scholastic aptitude rating. Applicants with a master's degree will be required to show more than a minimum success in graduate study, including at least one-third of their graduate credits of "A" quality.

SECONDARY EDUCATION

JOHN WITHALL, *Head of the Department*
164 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors Fagan, Fowler, McGarey, Patrick, Remaley, and Withall. Associate Member—Associate Professor Kozak.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the requirements, including residence, described in the earlier sections of this bulletin. For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the head of the Department of Secondary Education. When course work has been completed more than five years prior to admission to the D.Ed. or when it is transferred from another institution, the head of the department will determine its suitability for any part or all of the 15 hours required.

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the head of the Department of Secondary Education. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or geography. These programs require 6 credits in professional education approved in advance by the head of the department responsible for the minor field chosen; e.g., secondary education, agricultural education, etc.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

SECONDARY EDUCATION (SEC ED)

400. Introduction to Research Literature (3)
426. Teaching Mathematics in the Secondary Schools (4)
433. Teaching Social Studies in the Secondary Schools (4)
436. Teaching of Conservation of Natural Resources in the Secondary School (3)
438. Teaching Science in the Secondary Schools (4)
443. Reading Problems in the Secondary School (2-3)
445. (El.Ed. 445) Techniques in Remedial Reading (2-6)
451. Secondary Education in America (3)
453. Teaching English in the Secondary Schools (4)
454. Extracurricular Activities in the Junior and Senior High School (2-3)
472. Measurement of Achievement in the Secondary School (2-3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 406, and teaching experience.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Bot. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec.Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. (El.Ed. 546) Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabu-

lary development, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (3) Historical, psychological, social, and economic factors influencing secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

SLAVIC LANGUAGES AND LITERATURES

William R. Schmalstieg
Acting Head of the Department of Slavic Languages
127 Sackett Building

Degree Conferred: M.A.
Graduate Faculty: Senior Members—Professor Magner; Associate Professor Schmalstieg. Associate Member—Associate Professor Birkenmayer.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equivalent.
The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)
450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)

*1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. Russian Texts (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

501. Readings in Russian Literature (3-6) Prerequisite: Rus. 204.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. Russian Literature to Pushkin (3) Russian literary monuments in the original, 1100-1800.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

SLAVIC (SLAV)

500. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literature.

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

SOCIAL STUDIES

Hugo A. Meier
Chairman of the Committee on Social Studies
112 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18 credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

* No graduate credit is given for this course.

SOCIOLOGY

Donald P. Kent
Head of the Department of Sociology and Anthropology
237 Graduate Hall

Degrees Conferred: Ph.D., M.A.
Graduate Faculty: Senior Members—Professors Clark, Kent, Mather, and Theodorson; Associate Professor Dansereau. Associate Members—Professors Foreman and M. B. Matson; Associate Professor DeJong; Assistant Professor Westby.

Undergraduate preparation must include 12 credits in sociology and at least 6 in other social sciences. Students of exceptional ability who are deficient in undergraduate preparation may be accepted provided they make up their course deficiency without graduate credit.

A thesis is required of all M.A. candidates in this major.

SOCIOLOGY (SOC)

400. Advanced General Sociology (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)
408. Social Ecology (3)
413. Methods and Techniques of Social Research (1-6)
418. The Development of Social Thought (3)
422. History of Sociological Theory (3)
423. Population Research (3)
424. Social Change (3)
426. Public Welfare Policy and Services (3)
427. Social Case Work (3)
428. Seminar in Sociology (1-6)
429. Social Stratification (3)
444. Complex Organizations (3)
446. Political Sociology (3)
450. Community Organization (3)
454. Industry and the Community (3)
455. Occupations and Professions (3)
456. Readings in Sociology (1-9)
457. Field Work in Industrial Sociology (1-6)
470. Intermediate Social Statistics (4)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the overall structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

505. Current Social Theory (3) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

510. Field Work in Sociology (1-6)

513. Seminar in Sociological Research Problems: A. Research Techniques; B. Current Research (3-6) Prerequisite: 3 credits in statistics.

515. Seminar in Community Studies (3)

523. Population Problems (1-6)

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572. Methods of Sampling (3) Application of sampling techniques to sociological research.

SOLID STATE TECHNOLOGY

Rustum Roy
Chairman of the Committee on Solid State Technology
112 Research Unit I

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Brindley, Buessem, Fritz, Henisch, Hosler, Muan, Osborn, Vand, Walker, and Williamson; Associate Professors Cross, Cutler, Diethorn, Inman, Kline, Mulay, Vedam, and Weber; Mrs. Roy. Associate Members—Associate Professors Barsch and Vastola; Assistant Professors Gibbs, Kiusalaas, Knox, McKinstry, E. White, and W. White.

The aim of this program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this field must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined by the committee. Recommended course sequences for each year for students with different undergraduate background are prepared by the chairman and are available from the student's adviser.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. They should be interested

specifically in an interdisciplinary program of study and research. Dissertation research on various aspects of the solid state may be conducted in appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science; in the Materials Research Laboratory; and in the Ordnance Research Laboratory. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

Students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy the requirements; descriptions may be found under the appropriate department headings. Structure of Solids: Chem. 477, 516; Gchem. 512; Min. 463, 500; Mn.Sc. 421, 510, 520. Solid State Theory: Chem. 544, 545, 546, 547, 565, 567; E.Mch. 507, 516, 531, 540; Metal. 514; Phys. 410, 412, 470, 512-513, 517, 561-562, 571. Physical Properties of Solids: Cer.Sc. 506, 507, 508; Chem. 455; E.Mch. 414, 506, 530, 533, 546; Metal. 516; Nuc.E. 509. Chemical Reactions in Solids: Cer.Sc. 503, 504, 511, 512; Chem. 563, 564; F.Sc. 506, 515; Gchem. 513, 520; Metal. 508, 515, 518, 522.

SPANISH

Anthony M. Pasquariello
Head of the Department of Spanish, Italian, and Portuguese
212 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Senior Members—Professors Bleznick, Moser, Pasquariello, and Sturcken; Associate Professor Brentin. Associate Members—Associate Professor Dalbor; Assistant Professor Triolo.

The minimum requirement for admission to an advanced degree program will normally be 24 credits of post-intermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

SPANISH (SPAN)

400. Advanced Composition and Conversation (3)
404. The Evolution of Spanish (3)
413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)
*450. Spanish Institute (7-14)
452. Spanish Literature in the Romantic Period (3)
459. The Generation of 1898 (3)
472. The Contemporary Spanish-American Novel (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
482. Spanish Lyric Poetry (3)

* A maximum of 7 credits in one summer.

483. Spanish Drama of the 19th Century (3)
487. The Spanish Novel of the 19th Century (3)
498. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation.

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials.

505. Old Spanish: Phonology, Morphology, and Syntax (3)

506. History of the Spanish Language (3)

510. Spanish Descriptive Linguistics: Phonology (3)

511. Spanish Descriptive Linguistics: Morphology and Syntax (3)

515. Medieval Spanish Literature (3)

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry.

528. Spanish Renaissance and Golden Age Prose (3) Various types of novels with special emphasis on the picaresque; didactic literature; histories.

535. Seminar in Renaissance and Golden Age Literature (3-6) Nature and development of Spanish literature of the 16th and 17th centuries; topics will vary.

537. Lope de Vega and Calderón (3) Major works of these and other dramatists of the Golden Age.

540. Cervantes and His Works (3)

543. Spanish Literature of the 18th Century (3) Didactic literature, poetry, drama, and novel in the most representative writers in the century.

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós.

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others.

563. Contemporary Drama in Spain (3) The drama since 1898, to the present day: Benavente, Valle Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others.

564. Twentieth Century Hispanic Literature (3-6) Principal trends and works after the Generation of 1898 and *modernismo;* topics will vary.

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío.

580. History of the Spanish Essay (3) The principal essayists from the 16th century to the present.

585. Hispanic Poetry of the 19th and 20th Centuries (3) Various currents in the poetry of the Iberian peninsula and Latin America.

598. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature.

SPEECH

STANLEY F. PAULSON, *Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.
Graduate Faculty: Senior Members—Professors Arnold, Brubaker, Holtzman, Nelson, Oliver, Paulson, Schug, White, and Zelko; Associate Professors Fife and Phillips. Associate Members—Associate Professors Dunham and Hungerford; Assistant Professors Borden, Gregg, and Olbricht.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

A thesis is required of all M.A. candidates in this major.

SPEECH (SPCH)

400. TEACHING OF SPEECH (3) *Mr. Schug*
402. GENERAL SEMANTICS (3) *Mr. Phillips*
410. ENGLISH PHONETICS AND PRONUNCIATION (3) *Mr. Brubaker*
412. SPEECH CRITICISM (3) *Mr. Arnold*
417. DIRECTING FORENSICS (3) *Mr. Dunham*
425. (Brcst. 425) RADIO PROGRAMMING AND PERFORMANCE (3) *Mr. Nelson*
431. ANATOMY AND PHYSIOLOGY OF THE EAR AND VOCAL MECHANISMS (3) *Mr. Brubaker*
435. (Brcst. 435) RADIO AND TELEVISION PROGRAMMING (3) *Mr. Nelson*
437. (Brcst. 437) TELEVISION PROGRAMMING AND PERFORMANCE (3) *Mr. Hungerford*
450. DISCUSSION: RESEARCH AND THEORY (2-6) *Mr. Phillips*
475. STUDIES IN MASS PERSUASION IN THE DEMOCRATIC SOCIETY (3) *Mr. Hager*
476. ORIENTAL RHETORIC AND CONTEMPORARY PUBLIC ADDRESS IN THE FAR EAST (2) *Mr. Oliver*
477. CONTEMPORARY PUBLIC ADDRESS: THE GREAT DICTATORS (2) *Mr. Oliver*
478. CONTEMPORARY PUBLIC ADDRESS: ENGLISH AND AMERICAN SPEAKERS (2) *Mr. Gregg*
485. ADVANCED ORAL INTERPRETATION OF LITERATURE (3) *Mr. Hamilton*
490. PSYCHOLOGY OF SPEAKING AND LISTENING (3) *Mr. Holtzman*
494. TEACHING OF ENGLISH AS A SECOND LANGUAGE (3) *Mr. Holtzman*
496. SPEECH FOR TEACHERS (3) *Mr. Grove*

500. SEMINAR IN AMERICAN ORATORY (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. RESEARCH METHODS IN SPEECH (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Dunham*

505. HISTORICAL DEVELOPMENT OF SPEECH THEORY AND CRITICISM (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech.

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Dunham*

520. Seminar in Speech Science (2-4) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Mr. Brubaker*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Holtzman*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Mr. Zelko*

555. Speech Communication: Problems and Principles (2-4) Prevalent theories of speech influence. *Messrs. Borden, Oliver, and Phillips*

560. Public Address (2-4) Discussion and criticism of speech outline, manuscript, content, composition, and delivery. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Olbricht*

575. Research Problems in Speech (1-12) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology.

SPEECH PATHOLOGY AND AUDIOLOGY

Bruce M. Siegenthaler
In Charge of Graduate Programs in Speech Pathology and Audiology
2S Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.
Graduate Faculty: Senior Members—Professors McDonald and Siegenthaler; Assistant Professor Raabe. Associate Members—Associate Professors Berlin and Frick; Assistant Professor Haspiel.

Students may specialize in either speech pathology or audiology. Admission to study for the master's degree requires 27 credits in clinical speech and hearing, edu-

cation, and psychology, including at least 9 in speech pathology and/or audiology and a course in statistics. The major is one of the areas of study within the Department of Special Education.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing

counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

STATISTICS

James B. Bartoo, *Head of the Department of Mathematics*
228 McAllister Building

Degrees Conferred: Ph.D., M.A., M.S.
Graduate Faculty: Senior Members—Professors Bennett, Griffiths, Patil, and Schipper; Associate Professors Harkness, Prokasy, and Starling. Associate Members—Professor Bartoo; Assistant Professor Borden.

The modern science of mathematics and applied statistics is concerned with the general principles of dealing wisely with uncertainty and partial ignorance through mathematical probability.

To be admitted as a candidate for an M.A. or M.S. degree, the individual must possess an undergraduate degree with a background in mathematics including at least one and one-half years of calculus. Additional mathematical and statistical training is desirable. Admission to candidacy for the Ph.D. degree is granted only upon the recommendation of the faculty in statistics.

A Master of Arts, emphasizing mathematical statistics, requires a minimum of 24 credits of course work and a thesis (6 credits) or a minimum of 30 credits of course work and a term paper. A Master of Science, emphasizing applied statistics, requires a minimum of 24 course credits and a thesis (6 credits).

In addition to meeting the Graduate School requirements for the doctorate, a candidate for a Ph.D. in statistics must pass written qualifying examinations in three fields. These are ordinarily probability theory, mathematical statistics, and mathematical analysis. Candidates must also complete at least 4 credits in algebra and 4 credits in topology, with at least 2 credits in each at the 500 level. Programs and qualifying examinations for a student specializing in another area of statistics must be approved by the faculty in general and specifically by the candidate's committee.

STATISTICS (STAT)

400. Intermediate Statistical Analysis (3)
409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)
411. Practicum (1)
418. (Math. 418) Introduction to Probability Theory (3)

501. Theory of Statistics (3) Sufficiency and completeness, testing hypotheses, sequential analysis, chi-square tests, analysis of variance. Prerequisite: Stat. 410.

502-503. Analysis of Variance and Regression (3 each) Linear hypotheses, regression, analysis of variance and covariance, mixed and random effects models, multiple comparisons, designs. Prerequisites: Stat. 410; Math. 441 or 481.

504. Nonparametric Statistics (3) Goodness-of-fit tests, contingency tables,

analysis of multinomial and percentage data, multi-sample problems, special topics. Prerequisite: Stat. 410.

505. Multivariate Statistical Analysis (3) Statistical procedures associated with the multivariate normal distribution. Prerequisites: Stat. 410; Math. 441 or 481.

506. Sampling Theory (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

516. (Math. 516) Intermediate Probability Theory (3) Random walk and recurrent events, Markov chains, and the simplest time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) Advanced Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 501, Stat. 541.

541. (Math. 541) Mathematical Statistical Analysis (3) Probability spaces, random variables, distribution and characteristic functions, convergence theorems, univariate and multivariate distribution theory. Prerequisite: Math. 421.

542-543. (Math. 542-543) Advanced Theory of Statistics (3 each) Exact and asymptotic sampling distribution theory, rigorous treatment of sufficiency, completeness, estimation, and testing. Prerequisites: Stat. 410, 541.

577. (Math. 577) Special Topics in Probability and Statistics (3-12)

590. Seminar in Statistical Methods (1-6) Lectures on current statistical methods; presentation and discussion of literature treating various special topics in statistics.

THEATRE ARTS

Walter H. Walters, *Head of the Department*
103 Arts Building

Degrees Conferred: M.A., M.F.A.
Graduate Faculty: Senior Members—Professors Neusbaum, Smith, and Walters; Associate Professors Reifsneider and Yeaton. Associate Member—Assistant Professor Allison.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.

The M.F.A. program is planned to provide a professional emphasis. Students will take a core program and specialize in performance (acting, directing), dramatic writing, or production (scene design, technical direction, stage lighting, stage costuming).

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

Requirements for admission to the M.A. program are a broad undergraduate preparation; one course each in basic acting, directing, theatre crafts, and history of the theatre, or their equivalents; and 12 credits divided among speech, music, art and dramatic literature, or 9 credits in one of these fields.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, 3 of which must be in history of the theatre

In certain cases courses in speech, dramatic literature, art, music, dance, architecture, and other similar subjects may be accepted.

2. Auditions or submission of manuscripts, portfolios, photographs of theatre work, or other evidence of ability, according to specialization, as arranged by the student with the department.

All students in the M.A. and M.F.A. programs who lack the expected upper-class undergraduate courses in theatre may be requested to take additional course work without degree credit. All graduate majors are required to participate in University Theatre productions in positions of responsibility.

THEATRE ARTS (THEA)

404. Styles of Acting (3-6)
412. Advanced Scene Design (3-6)
413. Stage Lighting (3)
414. Stage Costuming (3)
415. Theatre Organization and Management (3)
421. Advanced Playwriting (3)
430. Ancient and Medieval Theatre (3)
431. Theatres of the Renaissance and the Orient (3)
432. History of the Modern Theatre (3)
433. Dance for the Theatre (3)
442. Creative Dramatics with Children (3)
443. Marionettes and Puppetry (3)
451. Directing (3-6)
452. Central Staging (3)
470. Theatre Production (1-6)
471. The European Film (3)
472. The American Film (3)
473. Motion Picture Techniques (3-6)
481. (Brcst. 481) Television Drama (3)
482. (Brcst. 482) Radio and Television Directing (3)

501. Directing (1-6 per term)

502. Technical Theory in Dramatic Production (3-6)

504. Styles of Acting (3-12)

506. The Contemporary Theatre (3-6)

507. Dramatic Theory (3-6)

512. Stage Design (1-6 per term)

521. Playwriting (3-12) Prerequisite: Thea. 421.

VOCATIONAL INDUSTRIAL EDUCATION

George L. Brandon
Head of the Department of Vocational Education
250 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Member—Professor Brandon. Associate Members—Professor Williams; Associate Professor Brantner.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial education is required for admission.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)
403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (4)
415v. Problems in Coordinating Vocational Education (3)
420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. Vocational Education for Administrators (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. Research in Vocational Education (3) Research techniques in vocational industrial education.

556v. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.

558v. State and Local Supervision and Administration (2-3) The more important recent problems in organization, supervision, and administration.

559v. Vocational Technical Education (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT

Bertil G. Anderson, *Head of the Department of Zoology*
208 Life Sciences Building
or
Wilber W. Ward, *Director of the School of Forest Resources*
101 Forestry Building

Degree Conferred: M.S.

Graduate programs in the field of wildlife management are offered by the Department of Zoology for students primarily interested in the animal aspects, and by the Department of Forestry and Wildlife for those primarily interested in the habitat aspects.

ZOOLOGY

Bertil G. Anderson, *Head of the Department*
208 Life Sciences Building

Degrees Conferred: Ph.D., M.S.
Graduate Faculty: Senior Members—Professors Anderson, Anthony, Cheng, Cooper, Davis, Hale, Schein, and Wright; Associate Professors Bellis, Grun, Houlihan, Lytle, and Pubols; Assistant Professor Hymer. Associate Members—Associate Professors Boyle and Wood; Assistant Professors Butler, Dunson, Taub, and Wickersham.

Students may specialize in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, parasitology, physiology, population dynamics, or wildlife management.

In order to undertake graduate work in zoology, students are required to have had 24 credits in zoology and related biological sciences; and they should have had calculus, physics, and chemistry through organic. A limited deficiency may be made up without degree credit while pursuing graduate work.

ZOOLOGY (ZOOL)

401.	(Pty.Sc. 401, Psy. 401) Animal Behavior (3)	*Mr. Hale*
403.	(Ent. 403) Systematics (3)	*Mr. Boyle*
405.	(Bot. 405) General Cytology (3)	*Mr. Grun*
408.	Mammalogy (4)	*Mr. Davis*
410.	General Limnology (3)	*Mr. Cooper*
415.	The Literature of Zoology (1)	*Mr. Anderson*
416.	The Methods of Research in Zoology (2)	*Mr. Anderson*
417.	Invertebrate Zoology (3)	*Mr. Lytle*
419.	General Animal Ecology (3)	*Mr. Bellis*
421.	Comparative Anatomy of Vertebrates (4)	*Mr. Taub*
422.	(Bot. 422) Advanced Genetics (3)	*Mr. Wright*
437.	Histology (4)	*Mr. Anthony*
440.	Embryology (4)	*Mr. Taub*
444.	Zoological Problems (1-6)	
448.	Ornithology (3)	*Mr. Wood*
450.	Ichthyology (3)	*Mr. Cooper*
461.	Animal Parasitology (3)	
471.	Vertebrate Physiology (3)	*Mr. Houlihan*
479.	General Endocrinology (3)	

505. (Bot. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Zool. 405 or 422. Spring term, odd years. *Mr. Grun*

509. Techniques in Wildlife Management (2) Evaluation of procedures designed to manage populations of game and fish; elements of statistics of birth and mortality rates; census methods. Fall term. *Mr. Davis*

512. Seminar (1) Review of current zoological literature. Required of graduate students majoring in zoology and entomology.

520. Special Topics (1-6)

524. (Bot. 524) Seminar in Genetics (1 per term) *Mr. Wright*

528. (Bot. 528) Population Genetics (3) Factors affecting gene frequency, genotype frequency, genotype-environmental interaction, and genetic relationship in natural and artificial populations. Winter term, even years.

533. (Bot. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

537. (Bot. 537, Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term.

541. Cellular and Comparative Physiology (3) Basic functions of animal cells and their variations in the animal kingdom.

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term. *Mr. Davis*

551. Fisheries Management (3) Basic principles underlying management of inland waters for fish production. Summer term, even years. *Mr. Cooper*

571. (Phsio. 571) Animal Physiology (2) Physiology of fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood, and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Phsio. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Phsio. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates and special senses. Prerequisite: 3 credits in physiology.

574. (Phsio. 574) Animal Physiology Laboratory (3) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisites: Phsio. 571, 572. Prerequisite or concurrent: Phsio. 573.

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals. *Mr. Lytle*

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Davis, Hale, and Schein*

583. Experimental Endocrinology (4) Problems in endocrinology designed to demonstrate the role of hormones in the regulation of physiological phenomena. *Mr. Anthony*

Other Elective Graduate Courses

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3) *Mr. Hicks*

THE ARTS (ARTS)

400. Contemporary Forms in Art, Music, Theatre (3)

BIOLOGY (BIOL)

501. Evolution (2) Selected Topics on the Evolution of Life.

BROADCASTING (BRCST)

425. (Spch. 425) Radio Programming and Performance (3) *Mr. Nelson*
435. (Spch. 435) Radio and Television Programming (3) *Mr. Nelson*
437. (Spch. 437) Television Programming and Performance (3) *Mr. Hungerford*
481. (Thea. 481) Television Drama (3)
482. (Thea. 482) Radio and Television Directing (3)
492. (Journ. 492) Public Affairs Broadcasting (3)

ENGINEERING (ENGR)

450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

531. Advanced Digital Computer Programming (3) Nonnumerical applications; symbol manipulation, syntactical analysis, and translation of artificial languages; heuristic methods, learning mechanisms, artificial intelligence.

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

FOOD TECHNOLOGY (FD T)

400. Effects of Processing on Food (3)
401. Sanitation and Quality Control (3)
402. The Thermal Process (1)

GEOLOGICAL SCIENCES (G SC)

402. Introduction to Organic Geochemistry (3)

GREEK (GREEK)

420. The Greek Historians (3)
421. Greek Tragedy (3)
422. Greek Comedy (3)
430. The Greek Philosophers (3-9)

INSTRUCTIONAL MEDIA (INST M)

435. Orientation to Instructional Media (2)
436. Production and Utilization of Graphic Stimulus Materials (3)
437. Production of Educational Motion Pictures (3)
443. Television in Education (3)

531. Organization and Administration of Media in Schools (2) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 435.

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

598. Seminar in Italian Literature (3-12) Common and individual research in special problems.

LABOR-MANAGEMENT RELATIONS (L M R)

411. Trade Union Administration (3)
421. Labor Education (3)
475. (Econ. 475) Theories of the Labor Movement (3)

LANDSCAPE ARCHITECTURE (L ARCH)

420. Landscape Ecology (3)	
425-426. Landscape Construction Problems (3 each)	*Mr. De Tuerk*
427. Landscape Construction Problems (2)	*Mr. De Tuerk*
434. Urban Park and Recreation Areas (3)	*Mr. Burggraf*
454-455. Landscape Design (3 each)	*Mr. Miller*
460-461-462. Advanced Landscape Design (4-8 each)	*Mr. Polakowski*
471. Park Systems (2)	*Mr. Wilson*
472. Planning and Public Policy (3)	*Mr. Burggraf*
473. Recreation Resource Planning (3)	*Mr. Polakowski*
474. Site Engineering Fundamentals (1)	

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LATIN (LATIN)

420. The Latin Historians (3)
428. Lucretius (3)
429. Quintilian (3)
430. Medieval Latin (3-6)
431. Juvenal (3)
436. The Teaching of Latin (3)

500. Latin Literature (3) Lectures and collateral readings on the major forms of Latin literature; readings in the original Latin to supplement the lectures.

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism.

510. Latin Seminar (3)

518. Latin Research (1-3) Prosecution of an assigned problem under the guidance of a member of the department.

LINGUISTICS (LING)

500. Generative Linguistics (3) Types of grammatical rule and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

501. Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

502. Historical Linguistics (3) Principles of comparative linguistics; language families; reconstruction of phonemic, morphemic, and syntactic structures of extinct languages.

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: 1 graduate course in linguistics.

MINERAL SCIENCES (MN SC)

411. Instrument Techniques Applied to Mineral Science Problems (1-3)
421. X-ray Diffraction (3)
431. Instrumentation for Physical Measurement and Control (3)

510. X-ray and Electron Diffraction Analysis as Applied to Minerals and Metals (2-4) Prerequisite: Mn.Sc. 421.

513. Semiconductor Physics (3) Electronic structure of solids; electronic transport phenomena; semiconductor materials; luminescence. Prerequisite: Phys. 400 or E.E. 32. *Mr. Henisch*

520. Electron Microscopy in Mineral Science Research (1-4) Prerequisite: Mn.Sc. 411, Unit B.

540. Solid State Structures and Reactions in Mineral Systems (2-4) Crystal chemical approach to solid state reactions, sintering, melting, hardness, thermal expansion, and behavior of matter under high pressure. *Mr. Weyl*

PORTUGUESE (PORT)

598. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems.

RELIGIOUS STUDIES (RL ST)

402. Contemporary Religious Thought (3)
409. Buddhism (3)
430. Religion and Morality (3)
440. Problems in Religious Studies (3-6)

502. Studies in Comparative Religions (3-6) Cross-cultural comparative studies of two or more major world religions.

505. Seminar in Asian Religions (3-6) Studies in selected Asian religions.

520. Early and Medieval Western Religion (3-6) Studies in Judaism and Christianity from the 1st century A.D. to 1500.

VETERINARY SCIENCE (V SC)

400. Veterinary Anatomy and Physiology (3)
401. Infectious Diseases of Domestic Animals (3)
420. General Animal Pathology (3)

515. (Micrb. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

520. Histopathology (3) Specific microscopic alterations and reactions developing in the living animal body when exposed to injurious agents or deprivations.

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PENN STA

1968-1969

The Pennsylvania State University Bulletin

Graduate Degree Programs

1968-1969

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE

FEBRUARY 1968

OFFICES OF THE GRADUATE SCHOOL

M. Nelson McGeary, *Dean*

University Park Campus
101 Willard Building
University Park, Pa. 16802
Telephone: Area Code 814, 865-6323

A. Witt Hutchison, *Assistant Dean*

King of Prussia Graduate Center
Route 23 and Henderson Road
King of Prussia, Pa. 19406
Telephone: Area Code 215, 265-5400

John M. Schempf, *Assistant Dean*

Capitol Campus Graduate Center
P. O. Box 230
Middletown, Pa. 17057
Telephone: Area Code 717, 944-5571

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*GRADUATE CALENDAR

WINTER TERM 1968

NOVEMBER 1967

3 Friday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1968

DECEMBER

4 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1968

JANUARY 1968

4-6 Thursday Noon to Saturday Noon—Winter Term Registration
4-6 Thursday Noon to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates
8 Monday—Winter Term Classes Begin 8 a.m.
8 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
16 Tuesday—Graduate Faculty Meeting
17 Wednesday—Last Date for Adding Courses to Approved Schedules
24 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
27 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee
29 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates

FEBRUARY

3 Saturday—Written French Language Examination for Advanced Degree Candidates
3 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
3 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser
17 Saturday a.m.—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

MARCH

2 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally
9 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in March
16 Saturday—Winter Term Classes End 12:25 p.m.
18-20 Monday to Wednesday—Final Examinations
23 Saturday—Commencement

SPRING TERM 1968

JANUARY 1968

29 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1968

*This calendar was approved by the Board of Trustees and is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

FEBRUARY

28 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1968

MARCH

28-30 Thursday Noon to Saturday Noon—Spring Term Registration

28-30 Thursday Noon to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates

APRIL

1 Monday—Spring Term Classes Begin 8 a.m.

1 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

10 Wednesday—Last Date for Adding Courses to Approved Schedules

16 Tuesday—Graduate Faculty Meeting

17 Wednesday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office

20 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee

20 Saturday—Written French Language Examination for Advanced Degree Candidates

22 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates

27 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates

27 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

MAY

11 Saturday a.m.—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

25 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally

JUNE

1 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in June

8 Saturday—Spring Term Classes End 12:25 p.m.

10-12 Monday to Wednesday—Final Examinations

15 Saturday—Commencement

SUMMER TERM 1968

APRIL 1968

18 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Summer Term 1968

MAY

20 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1968

JUNE

18-19 Tuesday p.m. and Wednesday—Summer Term Registration

18-19 Tuesday p.m. and Wednesday—Oral Examinations in Foreign Languages for Advanced Degree Candidates

20 Thursday—Summer Term Classes Begin 8 a.m.

20 Thursday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
29 Saturday—Last Date for Adding Courses to Approved Schedules

JULY
4 Thursday—Independence Day Holiday
6 Saturday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee
8 Monday—Last Date for a September Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
13 Saturday—Last Date for Final Oral Doctoral Examination for September Graduates
13 Saturday—Last Date for a September Graduate to Deliver Master's Thesis or Paper to Adviser
15 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates
16 Tuesday—Graduate Faculty Meeting
27 Saturday—Last Date for a September Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

AUGUST
3 Saturday—Written French Language Examination for Advanced Degree Candidates
10 Saturday—Last Date for a September Graduate to Rent Cap, Gown, and Hood Locally
17 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in September
29 Thursday—Summer Term Classes End 9:55 p.m.
30-31 Friday and Saturday—Final Examinations

SEPTEMBER
1 Sunday—Commencement

FALL TERM 1968

JULY 1968
18 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Fall Term 1968

AUGUST
19 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1968

SEPTEMBER
18-20 Wednesday to Friday—Fall Term Registration
18-20 Wednesday to Friday—Oral Examinations in Foreign Languages for Advanced Degree Candidates
23 Monday—Fall Term Classes Begin 8 a.m.
23 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

OCTOBER
2 Wednesday—Last Date for Adding Courses to Approved Schedules
9 Wednesday—Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
12 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee

14 Monday—Written Foreign Language Examination (Other than French) for Advanced Degree Candidates
15 Tuesday—Graduate Faculty Meeting
19 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates
19 Saturday—Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser
26 Saturday—Written French Language Examination for Advanced Degree Candidates

NOVEMBER
2 Saturday—Last Date for a December Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
16 Saturday—Last Date for a December Graduate to Rent Cap, Gown, and Hood Locally
23 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in December
28 Thursday—Thanksgiving Day Holiday

DECEMBER
2 Monday—Fall Term Classes End 9:55 p.m.
3-5 Tuesday to Thursday—Final Examinations
7 Saturday—Commencement

WINTER TERM 1969

NOVEMBER 1968
4 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1969

DECEMBER
3 Tuesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1969

JANUARY 1969
3-4 Friday and Saturday—Winter Term Registration
3-4 Friday to Saturday Noon—Oral Examinations in Foreign Languages for Advanced Degree Candidates
6 Monday—Winter Term Classes Begin 8 a.m.
6 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations
15 Wednesday—Last Date for Adding Courses to Approved Schedules
21 Tuesday—Graduate Faculty Meeting
22 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
25 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee
27 Monday—Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates

FEBRUARY
1 Saturday—Written French Language Examination for Advanced Degree Candidates
1 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
1 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

15 Saturday a.m.—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

MARCH

1 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally
8 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in March
15 Saturday—Winter Term Classes End 12:25 p.m.
17-19 Monday to Wednesday—Final Examinations
22 Saturday—Commencement

SPRING TERM 1969

JANUARY 1969

27 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1969

FEBRUARY

26 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1969

MARCH

26-28 Wednesday to Friday—Spring Term Registration
26-28 Wednesday to Friday—Oral Examinations in Foreign Languages for Advanced Degree Candidates
31 Monday—Spring Term Classes Begin 8 a.m.
31 Monday—Last Date for Registering with Foreign Language Departments for Written Language Examinations

APRIL

9 Wednesday—Last Date for Adding Courses to Approved Schedules
15 Tuesday—Graduate Faculty Meeting
16 Wednesday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
19 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
19 Saturday—Written French Language Examination for Advanced Degree Candidates
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26 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

MAY

10 Saturday a.m.—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
24 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally
31 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in June

JUNE

7 Saturday—Spring Term Classes End 12:25 p.m.
9-11 Monday to Wednesday—Final Examinations
14 Saturday—Commencement

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Marvin P. Thompson, Ph.D. (Michigan State) — *Adjunct Assoc. Prof. of Dairy Sci.*
S. Earl Thompson, D.Ed. (Illinois) — *Prof. of Hotel and Institution Administration*
Charles P. Thornton, Ph.D. (Yale) — *Associate Professor of Petrology*
George L. Thuering, M.S. (Penn State), M.E., P.E. — *Prof. of Industrial Engineering*
Thomas T. Thwaites, Ph.D. (Rochester) — *Associate Professor of Physics*
Eugene F. Timpe, Ph.D. (Southern California) — *Assoc. Prof. of Ger. & Comp. Lit.*
Nancy M. Tischler, Ph.D. (Arkansas) — *Assoc. Professor of Humanities and English*
Paul W. Todd, Ph.D. (California) — *Assistant Professor of Biophysics*
Stanley R. Townsend, Ph.D. (Northwestern) — *Professor of German*
Alan Trachtenberg, Ph.D. (Minnesota) — *Associate Professor of English*
Alfred F. Traverse, Ph.D. (Harvard) — *Associate Professor of Geology*
Alfred A. Triolo, Ph.D. (Illinois) — *Assistant Professor of Romance Languages*
Clarence E. Trotter, Ph.D. (Minnesota) — *Professor of Marketing*
Don Arthur Trumbo, Ph.D. (Michigan State) — *Professor of Psychology*
Albert G. Tsugawa, Ph.D. (Michigan) — *Associate Professor of Philosophy*
Loren D. Tukey, Ph.D. (Ohio State) — *Professor of Pomology*
Hugh B. Urban, Ph.D. (Penn State) — *Associate Professor of Psychology*
Betty van der Smissen, Re.D. (Indiana) — *Assoc. Prof. of Recreation*
David B. Van Dommelen, M.A. (Michigan State) — *Assoc. Prof., Fam. Hous. & Home Art*

VLADIMIR VAND, D.Sc. (Glasgow) — *Professor of Crystallography*
ABRAM W. VANDERMEER, Ph.D. (Chicago) — *Professor of Education*
EDWARD B. VANORMER, Ph.D. (Columbia) — *Professor of Education and Psychology*
FRANCIS J. VASTOLA, Ph.D. (Penn State) — *Assoc. Professor of Fuel Science*
KUPPUSWAMI VEDAM, Ph.D. (Indian Inst. of Sci.) — *Assoc. Prof. of Solid State Science*
ROBERT K. VIERCK, M.S. (Iowa), P.E. — *Professor of Engineering Mechanics*
BARRY VOIGHT, Ph.D. (Columbia) — *Assistant Professor of Geology*
CARL VOLZ, Ph.D. (Penn State) — *Professor of Electrical Engineering*
DONALD V. WADDINGTON, Ph.D. (Massachusetts) — *Asst. Professor of Soil Technology*
RICHARD H. WAGNER, Ph.D. (Duke) — *Assistant Professor of Botany*
DANIEL WALDEN, Ph.D. (New York) — *Assoc. Prof. of History and Social Science*
DARRELL E. WALKER, Ph.D. (California) — *Professor of Plant Breeding*
PHILIP L. WALKER, JR., Ph.D. (Penn State) — *Professor of Fuel Science*
WALTER H. WALTERS, Ph.D. (Western Reserve) — *Professor of Theatre Arts*
WILBER W. WARD, D.For. (Yale) — *Professor of Silviculture*
JOHN M. WARREN, Ph.D. (Wisconsin) — *Professor of Psychology*
THOMAS WARTIK, Ph.D. (Chicago) — *Professor of Chemistry*
JOHN B. WASHKO, Ph.D. (Wisconsin) — *Professor of Agronomy*
R. HADLY WATERS, Ph.D. (Pennsylvania) — *Professor of Transportation*
GEORGE H. WATROUS, JR., Ph.D. (Penn State) — *Prof. of Food Sci. and Ind.*
ARTHUR H. WAYNICK, Sc.D. (Harvard) — *Professor of Electrical Engineering*
WAYNE WEBB, Ph.D. (Iowa) — *Professor of Physics*
JON N. WEBER, Ph.D. (Toronto) — *Associate Professor of Geochemistry*
ROBERT L. WEBER, Ph.D. (Penn State) — *Associate Professor of Physics*
HARMER A. WEEDEN, Ph.D. (Cornell) — *Associate Professor of Civil Engineering*
STANLEY WEINTRAUB, Ph.D. (Penn State) — *Professor of English*
WINSTON R. WEISMAN, Ph.D. (Ohio State) — *Professor of Art History*
ARTHUR M. WELLINGTON, M.A. (Ohio State) — *Professor of Counselor Education*
GEORGE E. WELLWARTH, Ph.D. (Chicago) — *Associate Professor of English*
CLIFFORD C. WERNHAM, Ph.D. (Cornell) — *Professor of Plant Pathology*
FREDERICK L. WERNSTEDT, Ph.D. (U.C.L.A.) — *Professor of Geography*
PAUL N. WEST, M.A. (Columbia) — *Associate Professor of English*
DAVID L. WESTBY, Ph.D. (Michigan State) — *Assistant Professor of Sociology*
FRANCIS L. WHALEY, Ph.D. (Michigan) — *Associate Professor of Psychology*
RALPH H. WHERRY, M.A. (Penn State), C.L.U. — *Wm. Elliott Prof. of Life Insurance*
BENJAMIN A. WHISLER, Sc.D. (Harvard), P.E. — *Professor of Civil Engineering*
EUGENE E. WHITE, Ph.D. (Louisiana State) — *Professor of Speech*
EUGENE W. WHITE, Ph.D. (Penn State) — *Assistant Professor of Solid State Science*
JOHN W. WHITE, Ph.D. (Penn State) — *Assistant Professor of Floriculture*
WILLIAM B. WHITE, Ph.D. (Penn State) — *Associate Professor of Geochemistry*
GEORGE D. WHITFIELD, Ph.D. (Columbia) — *Associate Professor of Physics*
EDWARD W. WICKERSHAM, Ph.D. (Wisconsin) — *Assistant Professor of Zoology*
FRANS E. WICKMAN, Fil.dr.h.c. (Stockholm) — *Professor of Geochemistry*
THOMAS A. WIGGINS, Ph.D. (Penn State) — *Professor of Physics*
ARTHUR L. WILLIAMS, Ph.D. (Pennsylvania), C.L.U. — *Professor of Insurance*
EUGENE G. WILLIAMS, Ph.D. (Penn State) — *Professor of Geology*
WILLIAM A. WILLIAMS, Ed.D. (Pittsburgh) — *Professor of Industrial Education*
WILLIAM O. WILLIAMSON, Ph.D., D.Sc. (London) — *Professor of Ceramic Science*
JOHN J. WILLINGHAM, Ph.D. (Ohio State), C.P.A. — *Assoc. Professor of Accounting*
FERN K. WILLITS, Ph.D. (Penn State) — *Assistant Professor of Rural Sociology*
DONALD J. WILLOWER, Ed.D. (Buffalo) — *Professor of Education*
LOWELL L. WILSON, Ph.D. (South Dakota State) — *Assoc. Prof. of Animal Science*
LOUIS WINKLER, Ph.D. (Pennsylvania) — *Assistant Professor of Astronomy*
GEORGE F. WISLICENUS, Ph.D. (California Tech.), P.E. — *Prof. of Aerospace Eng.*
JOHN WITHALL, Ph.D. (Chicago) — *Prof. of Education and Educational Psychology*
FRANCIS H. WITHAM, Ph.D. (Indiana) — *Assistant Professor of Botany*

WARREN F. WITZIG, Ph.D. (Pittsburgh) — *Professor of Nuclear Engineering*
KENNETH H. WODTKE, Ph.D. (Utah) — *Assoc. Prof. of Psychology and Education*
GEORGE D. WOLF, Ph.D. (Pennsylvania) — *Assoc. Prof. of Soc. Sci. and History*
CARL H. WOLGEMUTH, Ph.D. (Ohio State) — *Assoc. Professor of Mechanical Eng.*
FRANCIS A. WOOD, Ph.D. (Minnesota) — *Assoc. Professor of Plant Pathology*
MERRILL WOOD, M.S. (Penn State) — *Associate Professor of Zoology*
HAROLD D. WRIGHT, Ph.D. (Columbia) — *Professor of Mineralogy*
JAMES E. WRIGHT, JR., Ph.D. (Cornell) — *Professor of Genetics*
LAUREN A. WRIGHT, Ph.D. (California Tech.) — *Professor of Geology*
PAUL J. WUEST, Ph.D. (Penn State) — *Assistant Professor of Plant Pathology*
JOHN N. YANOUZAS, Ph.D. (Penn State) — *Associate Professor of Management*
KELLY YEATON, M.A. (Washington) — *Associate Professor of Theatre Arts*
WILLIAM G. YENDOL, Ph.D. (Purdue) — *Associate Professor of Entomology*
PHILIP YOUNG, Ph.D. (Iowa) — *Research Professor of English*
FRANKLIN R. ZABRISKIE, Ph.D. (Princeton) — *Associate Professor of Astronomy*
JOSEPH ZAFFORONI, Ed.D. (Columbia) — *Associate Professor of Education*
SAM Y. ZAMRIK, Ph.D. (Penn State) — *Assistant Professor of Engineering Mechanics*
ARIAN ZARKOWER, Ph.D. (Cornell) — *Assistant Professor of Veterinary Science*
WILBUR ZELINSKY, Ph.D. (California) — *Professor of Geography*
HAROLD P. ZELKO, M.A. (Ohio State), LL.B. — *Professor of Speech*
JOHN H. ZIEGLER, Ph.D. (Penn State) — *Assistant Professor of Meat Science*
JOHN R. ZIMMERMAN, Ph.D. (Lehigh) — *Assoc. Prof. of Mechanical Engineering*
LEONARD N. ZIMMERMAN, Ph.D. (Cornell) — *Professor of Bacteriology*
HARRY D. ZOOK, Ph.D. (Penn State) — *Professor of Chemistry*
GEORGE S. ZORETICH, M.A. (Penn State) — *Professor of Art*

LECTURERS

MARY R. ADAIR, Ph.D. (Penn State) — *Assistant Professor of Special Education*
MARLLYN T. BOSWELL, Ph.D. (California) — *Assistant Professor of Mathematics*
RAYMOND H. BROWN, B.S. (Johns Hopkins) — *Associate Professor of Music*
RONALD E. BUCKALEW, Ph.D. (Illinois) — *Asst. Prof. of Fam. Econ. & Home Mgmt.*
CHEN-CHI CHANG, *m*Khan. P° (Kong Ka Monastery, Tibet) — *Assoc. Prof. of Rel. Studies*
WILLIAM S. DECKER, M.A. (Iowa) — *Associate Professor of Marketing*
GEORGE T. DESAU, D.Ed. (Penn State) — *Assistant Professor of Education*
AARON DRUCKMAN, B.A. (Penn State) — *Associate Professor of Philosophy*
JOANNE Z. FELDMAN, M.S. (Julliard) — *Assistant Professor of Music*
LEONARD FELDMAN, M.Mus. (Eastman) — *Assistant Professor of Music*
CHARLES FORNEY, JR., M.S. (Penn State) — *Assistant Professor of Computer Science*
RENA L. FOY, Ph.D. (Texas) — *Assistant Professor of Education*
IRVIN GARTNER, M.S.P.A. (Southern Cal.) — *Res. Assoc. in Public Administration*
STELLA R. GOLDBERG, Ed.D. (Columbia) — *Asst. Prof. of Child Dev. and Fam. Rel.*
KEITH A. HALL, Ed.D. (Indiana) — *Assistant Professor of Education*
WALTER H. HINDERER, Ph.D. (Munich) — *Assistant Professor of German*
DONALD E. HOPKINS, M.Mus. (Texas) — *Assistant Professor of Music*
BARTON L. JENKS, JR., M.S. (Princeton), P.E. — *Assoc. Prof. of Mechanical Eng.*
BRIAN JOHN, Dip.Ed. (University College of North Wales) — *Asst. Prof. of English*
DONALD W. JOHNSON, Ed.D. (Colorado) — *Assistant Professor of Education*
E. BRUCE JONES, Ph.D. (Colorado State), P.E. — *Assistant Professor of Meteorology*
EAMON M. KELLY, Ph.D. (Columbia) — *Assistant Professor of Finance*
DAWSON KIANG, B.A. (Harvard) — *Assistant Professor of Art History*
OSCAR A. KIMMEL, M.S. (Penn State) — *Associate Professor of Farm Mechanics*

Edgar H. Knapp, Ed.D. (Columbia) *Associate Professor of English and Education*
William L. Lewis *Associate Professor of Music*
Robert J. Lindahl, Ph.D. (Oregon) *Assistant Professor of Mathematics*
Richard E. Llorens, Ph.D. (Penn State) *Assoc. Prof. of Eng. Mch.* (King of Prussia)
Jeannette M. Lynch, M.A. (Cincinnati) *Asst. Prof. of Fam. Econ. & Home Mgmt.*
Robert E. Malcom, Ph.D. (Ohio State), C.P.A. *Associate Professor of Accounting*
Charles W. Mann, Jr., M.L.S. (Rutgers) *Assistant Professor of English*
Thomas D. Marro, D.Ed. (Colorado State) *Asst. Professor of Special Education*
Eugene R. Melander, Ph.D. (Minnesota) *Asst. Prof. of Business Statistics*
June Miller, M.Mus. (Yale) *Instructor in Music*
Thomas A. Morrison, Ph.D. (Penn State) *Assistant Professor of Accounting*
Raymond O. Murphy, D.Ed. (Penn State) *Assistant Professor of Education*
Hilding E. Nelson, Ed.D. (Michigan State) *Asst. Professor of Vocational Education*
H. Raymond Page, M.A. (Ohio State) *Assistant Professor of Music*
Joseph Paternost, Ph.D. (Indiana) *Assistant Professor of Slavic Languages*
Dante V. Scalzi, D.Ed. (Penn State) *Assistant Professor of Education*
Robert J. Scannell, Ph.D. (Penn State) *Assistant Professor of Physical Education*
Gordon M. Shedd, Ph.D. (Penn State) *Assistant Professor of English*
H. Dennis Sherk, Ph.D. (Penn State) *Assistant Professor of Education*
Charles J. Smith, M.S. (Carnegie Tech.), P.E. *Assoc. Prof. of Civil Engineering*
Champ R. Storch, D.Ed. (Penn State) *Assistant Professor of Education*
Smith C. Toulson, III, M.Mus. (Yale) *Assistant Professor of Music*
Richard D. Twark, B.S. (Kent State) *Lecturer in Business Statistics*
John Walmer, M.D. (Temple) *Associate Professor of Education*
Walter F. Westerfeld, M.S. (Penn State) *Professor of Botany*
Raymond T. Yeh, Ph.D. (Illinois) *Assistant Professor of Computer Science*

GENERAL INFORMATION

GRADUATE WORK at The Pennsylvania State University began in 1862 with two graduate students in residence. Two years later a "course for Graduates," which led to the degree of Master of Scientific Agriculture, was formally established, but for a number of years growth was slow and graduate instruction relatively unorganized. Eventually a committee of the University Senate was given the responsibility of guiding graduate study. Standards were established, and regulations were set up to govern the conferring of master's degrees and certain technical degrees. In 1922 the Graduate School was organized, and in 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy.

Today graduate study is offered in over 100 major fields, with fourteen advanced academic and professional degrees being conferred. During the academic year 1966-67, 3,500 to 4,000 graduate students were enrolled each term, and 1,208 advanced degrees were conferred, of which 259 were doctorates. The faculty of the Graduate School, numbering about 1,000, controls all academic matters pertaining to the School, subject to review by the University Senate.

GRADUATE CENTERS—University Graduate Centers have been established in the Philadelphia and Harrisburg areas. They operate under the immediate direction of a resident assistant dean of the Graduate School and have full-time resident faculty members as well as part-time staff. Programs to be offered in a Center will depend upon its location, the degree of interest, and the availability of qualified students in the immediate area.

The King of Prussia Graduate Center near Philadelphia, which opened in 1963, currently has an enrollment of more than 450 students. Its program leads to the degree of Master of Engineering with a major in Engineering Science.

The Graduate Center at Harrisburg, which opened in 1965 as the Susquehanna Valley Graduate Center, is now the Capitol Campus Graduate Center. Its present enrollment is approximately 100. Programs leading to the degrees of Master of Engineering, Master of Education, and Master of Administration are currently offered; others are in the planning stage.

Interested students are urged to write directly to the dean at the Center for information on programs and courses. Addresses are given on the inside of the front cover of this bulletin.

NEW MEDICAL CENTER—A gift of $50,000,000 from the Milton S. Hershey Foundation has made possible the establishment of a medical center near Harrisburg, Pennsylvania, for which facilities are now under construction. The first class of medical students entered in Fall 1967. The Ph.D. program will emphasize medical research and operate in close cooperation with related departments on the University Park Campus.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at Penn State by scheduling relevant courses and research at University Park. Similarly a graduate student with an appropriate major at Penn State may earn credits at Jefferson which, upon advance approval by his major department, will be accepted in partial fulfillment of degree requirements at Penn State.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in this publication, the *Manual for Graduate Students,* and the *Thesis Information Bulletin,* and for meeting the standards and requirements expressed by these regulations. The *Manual,* which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Dean's office soon after admission.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program. It operates at a higher level, demands scholarship of a higher order, and emphasizes research and creativity, with a minimum of formal requirements and a maximum of student initiative and responsibility.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number which can be accepted will vary with departments and from term to term. In some fields all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted. The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the University's resources to provide graduate programs of outstanding quality.

Admission is granted jointly by the Dean of the Graduate School and the department in which the student plans to do his major work. Blanks to be used in making formal application for admission can be obtained from the Graduate School office. In general, a student may begin his graduate work in fall, winter, spring, or summer. Prospective students may write directly to the head of any department concerning graduate work in that specific field.

CREDENTIALS—An applicant for admission should provide complete credentials, in duplicate, sent directly from other institutions to the Dean of the Graduate School at least two months prior to the opening of the term in which he plans to begin his graduate program. If the applicant has attended more than one institution, two official transcripts of the work covered at each institution are required. This applies to the complete academic record, both undergraduate and graduate.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements for an advanced degree.

UNQUALIFIED ADMISSION—For unqualified admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must have maintained during his junior and senior years a minimum grade point average equivalent to 2.50 on The Pennsylvania State University grading scale (approximately half B and half C). Finally, he must ordinarily have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of required work depending upon the field of advanced study which the student proposes to enter. The specific courses and the total number of undergraduate credits required can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. The minimum grade point average of 2.50 during the last two

undergraduate years is a general requirement of the Graduate School. Individual departments may require a higher average for admission in their fields.

The above requirements apply particularly to the student who has recently completed an undergraduate program and is about to begin graduate study. An applicant who has obtained a graduate degree or done a substantial amount of high-quality graduate work at a recognized graduate school will be evaluated largely on the basis of the graduate record. For a mature person, recognized attainment in a professional field will be considered, and reduced weight will be given to old undergraduate records.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School and as a consequence will be required to cease attending any 500-level courses for which he may have registered. He may continue to attend courses below the 500 level provided he applies for and is accepted for registration as an adjunct student.

CONDITIONAL ADMISSION—When a department has space for additional students, an applicant whose grade point average is below 2.50 may be admitted conditionally for one term under the following circumstances: He must have had at least one year of significant experience after receiving the bachelor's degree and be recommended for admission by his major department. The applicant's credentials must be on file in the Graduate School office at least three months before the proposed date of registration. He must devote full time to his studies during the term for which he is conditionally admitted unless he is a student at one of the Graduate Centers or in a comparable situation where a full-time program is not available. In the latter case he may continue on a part-time basis until the equivalent of a full term has been completed. At the end of the student's first term (or equivalent first term in the case of a part-time student) his conditional admission will terminate. If an average grade of 3.00 has been earned, he may continue as a student with unqualified admission. If an average of 3.00 has not been attained, the student may not register again as a graduate student.

ADVISERS—To assist the student in planning his program, the head of his major department will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to make an appointment for an initial language proficiency interview at the Language Testing Center for International Students, 317 Sparks Building. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. Remedial work will be prescribed as indicated by the tests.

GUESTS OF THE UNIVERSITY—The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctor's degrees who may be visiting the University for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade point average of 3.00). Any senior with a 3.50 grade point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students with a B average or better may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400 and 500 series courses toward an advanced degree at Penn State. Upon admission to the Graduate School such credits as are relevant to the graduate field of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major and minor departments. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

STUDENT CONDUCT

The University expects that students will conduct themselves in accordance with the standards normally followed by educated men and women and in accordance with the laws of the Nation, state, and borough. The right is reserved to sever at any time the University connection of any student whose influence is found to be injurious to the standard of morals and scholarship of the student body, or whose conduct is prejudicial to the name of the University.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committe in charge of the graduate major or by the chairman of the student's doctoral committee.

CLASSIFICATION

At the time of admission to the University a student is classified as a graduate, adjunct, or undergraduate student depending upon his objectives and qualifications. A graduate student may be admitted either as a degree student or a non-degree student depending upon his objectives. After admission to one of these categories, any change to the other must be arranged through the Graduate School Office.

DEGREE STUDENTS—Persons who plan to become candidates for advanced degrees at The Pennsylvania State University and who have been formally admitted for advanced study in a particular field are designated as degree students. The program of study is developed under the guidance of an adviser appointed by the head of the student's major department.

A degree student who has passed a candidacy evaluation is classified as a doctoral candidate.

NON-DEGREE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a non-degree student. This classification includes those who plan to transfer credits to another institution and those who plan a special program of study not leading to an advanced degree. The number of non-degree students who can be admitted is limited, and it is increasingly

difficult to provide for them because of the limitation of total enrollment. Preference is given to students in degree programs.

If a non-degree student wishes to consult an adviser, one will be appointed upon request to the department head most closely associated with the student's field of interest. The student's status and standing will be reviewed by the Dean of the Graduate School at each registration. He may remain a non-degree student longer than one term only with the permission of the Dean, and for definite and good reasons.

ADJUNCT STUDENTS—An adjunct student is not a graduate student, inasmuch as he has not been admitted to the Graduate School, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses provided he has attained at least junior standing in college.

Credits earned as an adjunct student may not ordinarily be applied subsequently toward an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until his program is near completion, he is expected to register for each term in which he proposes to do either course work or research toward his thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of his program the situation will determine the requirements for the student's registration.

CONTINUITY OF REGISTRATION—A student who registers at University Park without interruption for each of the three terms in the September to June interval, for all four terms each year, or for each summer term is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Dean of the Graduate School at least one month before the time of registration for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term—Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered at University Park for the preceding fall term.

Spring Term—Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE—For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs. The credit load will be reviewed by the Dean of the Graduate School at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done away from the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM—A candidate for the Ph.D. degree who is following the new regulations, which went into effect in the fall term 1967, is required to register continuously (at least three terms per calendar year) from the time he has both passed the comprehensive examination and met the three-term full-time academic requirement until his thesis is accepted by his doctoral committee, regardless of whether he is working on his thesis during this interval. These candidates are also required to be registered for the term in which they graduate.

Other doctoral candidates and master's students may be required to register for a normal credit load because of their appointment status. If not, and if they have earned more than 90 or 30 credits, respectively, and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student who has met the minimum requirements for his degree and is now completing his research and thesis writing off-campus is not required to register, even if he comes to the campus several times each term to see his adviser.

A student, other than one following the new Ph.D. requirements, is not required to register for his final term in order to graduate or in order to make minor revisions to his thesis and/or to take a final examination for his degree.

TIME OF REGISTRATION—Registration days are indicated in the calendar at the beginning of this bulletin.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control, the student may be granted permission by his instructors to miss a few class meetings, it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the length of time he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

LOADS, ACADEMIC AND EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule in planning his academic program.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their Graduate School experience to a maximum extent. Therefore the Graduate School reserves the right to deny admission or registration to part-time students who (a) propose schedules of few credits which seem to reflect little real interest in graduate work or would not seem to require serious effort, or (b) wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality in their graduate work.

"Doing graduate work" means more than doing what is required in courses or in research. It means living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Overloads make it difficult and often impossible to do graduate work so conceived. Hence the following "protective" schedule of permitted loads for employed students has been adopted:

EMPLOYMENT	ACADEMIC LOAD
0 hours per week	8-10 credits allowed
10 hours per week	7- 9 credits allowed
20 hours per week	5- 7 credits allowed

30 hours per week	4- 5 credits allowed
40 hours per week	1- 4 credits allowed

This means, for example, that anyone working twenty hours per week (about half-time) whether as a half-time graduate assistant, as an employee on campus, or as an employee off-campus, will be limited in the amount of graduate work for which he may register to about three-fifths of a normal full-time load (i.e., to 5-7 credits). The word employment is used in a very general sense and includes work for indirect compensation, such as housekeeping, working in the family business, maintaining a large vegetable garden, etc. Hence, all students who are thus employed will be expected to adjust their academic loads accordingly. Exceptions, in the case of students who have demonstrated unusual ability, must be arranged with the Dean of the Graduate School at the time of registration. (See also Visiting and Auditing Classes.)

A student holding a fellowship, graduate assistantship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting, nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no credit and cannot subsequently secure credit for work done in the course.

A student who, because of his status as a graduate assistant or fellow, is required to register for a certain minimum number of credits is not permitted to count those courses for which he is registering as an auditor for this purpose. The 1G and 2G language courses are an exception. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for the course as an auditor.

SELECTIVE SERVICE—A request for deferment must be addressed to the local board by the student himself. Although the University cannot make this request, it can supply local boards with information needed in support of a request for deferment.

To have his local board informed of his formal admission to the Graduate School, a student must supply the essential Selective Service information and request the Records Officer to inform the board.

To have his local board informed of his registration and status as a student, a new graduate student must request the Records Officer to so inform the local board. If so requested, a report will be sent shortly after the beginning of the first term for which the student registers. A student is certified to be a full-time student insofar as Selective Service is concerned if he schedules at least 8 credits (auditing a course does not count), or if he holds an appointment as a quarter-time or half-time graduate assistant, or if he is serving an internship or holding a traineeship under approved conditions.

If at any time a student changes his status from full-time to part-time, fails to make satisfactory progress, or makes a drastic change in his declared goal, his local board will be notified. If a student changes his status from part-time to full-time and wishes the local board to be informed, he must request the Records Officer to do so. When a student receives a master's degree, it will be assumed his program is terminated, and his board will be so informed unless there is clear prior indication in the Records Office of the student's intention of proceeding with a doctoral program.

At the end of each spring term the Records Office reports to the local boards the

status of all graduate students for whom a report was made during one of the three previous terms.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade point average of 3.00 for work done at this university is required for graduation in the case of all candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later.

In addition to the quality grades listed above, two symbols, "Def." (deferred) and "R," may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "Def." in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol "R" in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. An "R" remains on the student's transcript permanently. If, after having submitted a series of "R" symbols, the instructor reports a grade of A, B, C, D, or F for a specific term, this grade is considered to apply to the preceding series of registrations and to denote the quality of that entire series.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate (by filing a diploma card or, if a diploma card is already on file, by requesting that it now be transferred to the active file), and to pay thesis fees at the beginning of the term in which he expects to receive an advanced degree. Deadlines are given in the calendar at the beginning of this bulletin.

See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation. Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School.

All degrees conferred are tentative until final grade reports have been received, even though the student's name may have appeared in the commencement program.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus—8 or more credits, total charge of $150 for Pennsylvanians

and $350 for non-Pennsylvanians; 7 or fewer credits, $16 per credit for Pennsylvanians and $44 per credit for non-Pennsylvanians. These rates also apply to off-campus research and other approved individual study.

Graduate and Continuing Education Centers—8 or more credits, total charge of $130 for Pennsylvanians and $350 for non-Pennsylvanians; 7 or fewer credits, $14 per credit for Pennsylvanians and $44 per credit for non-Pennsylvanians.

Vocational Education Programs—7 or fewer credits, $22 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Graduate Dean's Office for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile of the one admitted (or of his parents, if he is a minor) within the Commonwealth for a period of at least twelve months immediately preceding the date of such petition for reclassification; and, in addition, such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following the twelfth month after such change has taken place.

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor not later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES—In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Admission to the Graduate School	$ 10.00
Change of schedule, each change	2.00
French reading examination	6.00
Music, individual lessons	30.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00
Special dissertation fee for Ph.D. candidates (601)	75.00
Special dissertation fee for Ph.D. candidates (611)	25.00
Thesis binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Transcript of records (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

A graduate student planning to operate a motor vehicle in the State College area should secure a copy of the leaflet *Parking and Traffic Regulations* from the Traffic Violations Officer.

TAXES—Depending upon their residence classification and appointment status, graduate students may be subject to taxes while at the University. In general, graduate assistants will be liable for the federal income tax and the State College borough wage tax on their stipends. A graduate student who is classified as a resident of one of the civil subdivisions of Centre County may also be subject to local taxes, including school tax. Details are given in the *Manual for Graduate Students.*

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fire-resistant, one-story, steel framework buildings. Forty-six one-bedroom units rent for $75 per month and thirty-two two-bedroom units rent for $85. Rent includes utilities except for electricity. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle, opened in 1960, has 144 one-bedroom and 72 two-bedroom apartments in 16 two-story buildings of brick and frame construction. The units rent for $82.50 and $92.50 per month, including all utilities. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator, and each bedroom has a built-in chest of drawers; otherwise the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age or with children who will become school age during the term of the lease cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children.

Atherton Hall, located near the Hetzel Union Building and reserved exclusively for single graduate men and women, provides residence hall room accommodations without food service. Double, single, or single occupancy of double rooms are available at $130, $145, and $155 per term, respectively. The Hetzel Union Building cafeteria and snack bar are available for meals.

Separate dining hall meal tickets for one of eight campus dining halls may be purchased for $190 per term. Twenty-one meals per week are served beginning with registration and ending with final examinations.

For application forms and information on apartments and residence or dining halls, contact the Assignment Office for Campus Residences, 101 Shields Building, University Park, Pa. 16802; telephone Area Code 814, 865-7501.

Information on other living accommodations available in the community may be obtained through the Chamber of Commerce, 129 W. Beaver Ave., State College, Pa. 16801; telephone Area Code 814, 237-7644. The cost of apartments or rooms in private homes or lodging houses varies considerably, depending upon the type of accommodations desired, and arrangements can best be made by personal visit to the area.

Prospective graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be very difficult to find convenient housing at the last minute.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

STATEMENT OF NON-DISCRIMINATION

In the selection of individuals for all types of financial aids for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of race, creed, color, or national origin of any applicant.

ASSISTANTSHIPS

Approximately 1,700 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some departments. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department for information and application forms. Appointments are made upon the recommendation of the department head, subject to the student's admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship requires a continuing demonstration of good scholarship.

The assistantships vary as follows:

QUARTER-TIME—The student may schedule 7-9 credits, receives a stipend in the range $270-$480 plus a grant-in-aid which covers tuition, will be required to give a maximum of ten hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

HALF-TIME—The student may schedule 5-7 credits, receives a stipend in the range $480-$1,020 plus a grant-in-aid which covers tuition, will be required to give a maximum of twenty hours of service per week for twelve weeks, and will

be considered to be following a full-time course of instruction under Selective Service regulations.

THREE-QUARTER-TIME—The student may schedule 4-5 credits, receives a stipend in the range $810-$1,350 plus a grant-in-aid which covers tuition, will be required to give a maximum of thirty hours of service per week for twelve weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by arrangement with the Dean of the Graduate School, provided the credit load and the service load are properly balanced in each term and the total credit load over a series of terms is in conformity with the specified limits.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term without service if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an extra earned grant-in-aid form from the head of the department in which he has held the assistantship and must follow the instructions on the form in making application.

A graduate assistant may not accept employment, either at the University or elsewhere, during the period for which service to the University is required under the appointment (twelve weeks per term).

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than 500 fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows and trainees carry a full-time graduate program, receive a stipend which varies with the award, and usually receive a grant-in-aid paid by the donor of the award to provide for all tuition. They may not accept employment during the term of their appointment (except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

GRADUATE SCHOOL FELLOWSHIPS—A small number of fellowships, each paying a stipend of $2,500 for the fall, winter, and spring terms and providing a grant-in-aid to cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding advanced graduate students in any field, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences. An applicant must have completed at least one full year of graduate study prior to beginning the fellowship tenure and be a candidate for the doctoral degree.

Applications should be addressed to the Dean of the Graduate School and must be received by February 8 to be considered for the following fall, winter, and spring.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES—At least 230 such awards, with various stipends, are granted through individual departments. Information and application forms may be secured from the head of the major

department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1967-68:

Accountants Fund, Inc., Dissertation Fellowship—Available to a Ph.D. candidate in business administration who is preparing to teach accounting; stipend variable up to $5,000.

Amelia Earhart Fellowship—Available to a woman graduate student in aerospace engineering; stipend $2,400.

American Chemical Society Fellowship—Available to a graduate student in fuel science; stipend $2,280.

American Chemical Society Fellowships (2)—Open to graduate students in geochemistry, mineralogy, and solid state science; stipend $2,400.

American Chemical Society Fellowship—Available to a graduate student in geology; stipend $2,400.

American Cyanamid Fellowship in Chemistry—Available to a graduate student in chemistry for the final year of study leading to the Ph.D. degree; stipend $1,800.

American Iron and Steel Institute Fellowships (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400.

Armstrong Doctoral Fellowship in Business Administration—Available to a Ph.D. candidate in business administration; stipend $3,100.

Armstrong Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry; stipend $640.

Atomic Energy Commission Graduate Traineeships in Nuclear Reactor Operations and Utilization (5)—Open to graduate students in nuclear engineering. Stipends comparable to the AEC Special Fellowships.

Carborundum Corporation Fellowship—Available to a graduate student in mineral preparation; stipend $2,400.

Continental Oil Company Fellowship—Available to a graduate student in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

Continental Oil Company Fellowship in Petroleum Economics—Available to a graduate student in mineral economics for studies in petroleum economics; stipend $2,280.

Diamond Alkali Company Foundation Summer Fellowship—Available to a graduate student in chemical engineering; stipend $600.

du Pont Summer Fellowships (6)—Open to graduate students in chemical engineering; stipend $600.

Ernst and Ernst Fellowship—Available to a master's candidate in accounting; stipend $1,000.

Esso Research and Engineering Fellowship in Chemistry—Available to an advanced graduate student for one year of study leading to the Ph.D. degree; stipend $1,800-$2,200.

W. S. Elliott Fellowship—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

Fisher-Price Fellowship—Available to an advanced graduate student in child development and family relationships and especially interested in work with young children; stipend $1,950.

Ford Motor Company Fellowship—Available to a graduate student in mechanical engineering; stipend $2,400.

General Foods Fund Fellowships (2)—Open to graduate students with a major in the College of Human Development; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

General Telephone and Electronics Foundation Fellowship—Available to a graduate student in electrical engineering; stipend $3,000.

Gulf Oil Company Fellowship in Petroleum and Natural Gas Engineering—Available to a graduate student for work in petroleum production; stipend $2,400.

Hamilton Standard Fellowship—Available to a graduate of this university in aerospace, electrical, and mechanical engineering, engineering mechanics, or physics; stipend $1,800.

Haskins and Sells Foundation Fellowship—Available to a graduate student in accounting; stipend $2,500.

H. R. Imbt Services, Inc., Fellowship—For graduate work in civil engineering in the field of civil engineering construction; stipend $2,400.

International Business Machines Corporation Fellowship—Available to an outstanding advanced graduate student in the humanities or social sciences when his doctoral research is amenable to treatment by a digital computer; stipend $2,400-$3,000. Apply to the Dean of the Graduate School.

International Lead Zinc Research Organization Fellowship—In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to a student in ceramic science; stipend $3,000.

International Lead Zinc Research Organization Fellowship—In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in solid state science; stipend $2,540.

Joseph M. Johnston Memorial Scholarship—Available to a student whose program is related to floriculture; stipend variable.

Marathon Oil Company Fellowship—Available to a graduate student in petroleum and natural gas engineering; stipend $2,280.

National Lead Company, Titanium Alloy Manufacturing Division Fellowship—In support of research on the chemistry and physics of titanium and zirconium compounds of interest to the chemical and ceramic industries; stipend $2,600.

National Steel Corporation Fellowship—Available to a graduate student in metallurgy; stipend $2,880.

Edward Orton, Jr., Ceramic Foundation Fellowship—Available to a student in ceramic science for studies relating to kiln-fired ceramic materials; stipend $2,400.

Owens-Corning Fiberglas Fellowship in Ceramic Science—Available to a graduate student in ceramic science; stipend $3,000.

Owens-Illinois Fellowship—Available to a graduate student in ceramic science for studies in glass science and technology; stipend $3,000.

Pennsylvania Cooperative Fishery Unit Fellowships (3-4)—Open to graduate students in zoology; stipend $2,400-$2,460.

Pennsylvania Cooperative Wildlife Research Unit Fellowships (4)—Open to graduate students in forestry, zoology, and related fields; stipend $2,400.

Pennsylvania Electric Association Fellowship—For graduate work in mineral economics on potential markets for fly ash; stipend $2,400.

Pennsylvania Natural Gas Men's Fellowship—Available to a graduate student in petroleum and natural gas engineering for studies in gas technology; stipend $2,000.

Price Waterhouse Foundation Fellowship—Available to a Ph.D. candidate in accounting; stipend variable up to $5,000.

Radio Corporation of America Fellowship—Available to a graduate student in electrical engineering; stipend $2,100-$3,000.

Shell Companies Foundation Fellowships (2)—Open to advanced graduate students in two of these fields in rotation: chemical engineering, chemistry, and petroleum engineering; stipend $2,500.

Shubert Fellowship in Playwriting—Available to a graduate student in theatre arts; stipend $2,500.

Socony-Mobil Fellowship—Available to a graduate student in chemical engineering; stipend $3,000-$3,500.

Speer Carbon Fellowship—Available to a graduate student in fuel science for studies on carbon; stipend $2,680-$3,500.

Sprague Electric Company Fellowship—Available to a graduate student in ceramic science or solid state science; stipend $2,400.

Stackpole Carbon Fellowship—Available to a graduate student in fuel science for studies on carbon; stipend $3,600.

STACKPOLE FERRITE FELLOWSHIP—Available to a graduate student in ceramic science or solid state science; stipend $3,000.

STAUFFER CHEMICAL COMPANY FELLOWSHIP IN CHEMISTRY—Available to a graduate student in chemistry for research on organometallic compounds; stipend $1,800.

SUN OIL COMPANY FELLOWSHIP IN CHEMISTRY—Available to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

SURFACE COMBUSTION FELLOWSHIP—Available to a graduate student in fuel science for studies in the field of gaseous combustion; stipend $3,600.

TEXACO FELLOWSHIP IN GEOPHYSICS—Available to a graduate student in geophysics; stipend $2,760.

UNION CARBIDE SUMMER FELLOWSHIPS (5)—Open to graduate students in chemical engineering; stipend $600.

U. S. OFFICE OF EDUCATION FELLOWSHIPS IN EDUCATION OF EXCEPTIONAL CHILDREN (15)—Open to graduate students being prepared as leadership personnel in the education of the mentally retarded and the emotionally disturbed; stipend $2,000-$2,800 plus dependency allowance. Apply to the Head of the Department of Special Education.

U. S. OFFICE OF EDUCATION EXPERIENCED TEACHER FELLOWSHIPS IN GEOGRAPHY (15)—Open to secondary school teachers with at least one year of experience, preferably three years, who are released from their school systems and promise to return after the year's study; stipend $4,000 plus dependency allowance.

U. S. OFFICE OF EDUCATION FELLOWSHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY: WORK WITH THE SPEECH-HANDICAPPED (5); WORK WITH THE HARD-OF-HEARING (4)—Open to graduate students specializing in these fields; stipend $2,000-$2,800 plus dependency allowance. Apply to the Director of the Speech and Hearing Clinic.

U. S. OFFICE OF EDUCATION TRAINEESHIPS IN EDUCATIONAL PSYCHOLOGY (6)—Open to graduate students majoring in educational psychology and preparing for careers as educational research workers; stipend $2,400-$2,800 plus dependency allowance.

U. S. OFFICE OF EDUCATION PROSPECTIVE TEACHER FELLOWSHIPS IN FAMILY LIFE AND SEX EDUCATION (6)—Open to master's degree students majoring in child development and family relationships and preparing for teaching family life and sex education in elementary or secondary schools; stipend $2,000-$2,200 plus dependency allowance.

U. S. OFFICE OF EDUCATION, BUREAU OF RESEARCH, RESEARCH TRAINEESHIPS IN PHYSICAL EDUCATION AND RECREATION (8)—Open to graduate students pursuing the doctoral degree in preparation for careers in research; stipend $2,400-$2,800 per year plus dependency allowance.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN AIR POLLUTION (26)—Open to selected graduate students in the physical sciences, biological sciences, and social sciences; stipend $3,000-$3,600 plus dependency allowance. Applications and information available through the Center for Air Environment Studies.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN CLINICAL PSYCHOLOGY (18)—Open to selected graduate students in this area of psychology; stipend $1,800-$3,000.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN MICROBIOLOGY (4)—Open to selected graduate students in microbiology; stipend $2,400-$2,800.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN PUBLIC HEALTH NUTRITION (5)—Open to selected graduate students in foods and nutrition; stipend $3,000.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN SANITARY ENGINEERING (5)—Open to graduate students in sanitary engineering; stipend $3,600-$5,000.

UNITED STATES STEEL FOUNDATION FELLOWSHIP—Available to a graduate student in the College of Earth and Mineral Sciences for studies related to steel-making; stipend $2,880.

U. S. VOCATIONAL REHABILITATION ADMINISTRATION TRAINEESHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY (11)—Open to graduate students specializing in speech pathology, audiology, or education of the deaf; stipend $2,400-$2,800.

U. S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in Counselor Education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (5)—Open to selected advanced graduate students in this area of psychology; stipend $3,500-$6,500, not including tuition and fees.

Walter Thomas Memorial Scholarship—Available to a student studying the nutrition of horticultural crops; stipend variable.

In addition, grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS—Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See statement on non-discrimination, p. 47.)

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelor's degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations, designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Associated Universities, Oak Ridge, Tennessee. About 200 will be awarded.

National Aeronautics and Space Administration Predoctoral Traineeships in Space-Related Science—The National Aeronautics and Space Administration awards training grants to various recognized universities to increase the supply of scientists and engineers in space-related science and technology in order to meet the growing needs of the federal government's space research program. These grants permit a university to award a specified number of traineeships in science and engineering fields. The awards compare favorably with the best fellowships. In 1967-68 the University had thirty-eight of these traineeships in physical science, biological science, and engineering fields; more may be available for 1968-69. No institution will know whether it has any available until late in the fall. An applicant should write to the graduate dean at the institution of his choice, or to the head of the department in his graduate field.

National Defense Graduate Fellowships—Under Title IV of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education makes an allotment of three-year fellowships to approved institutions which have applied for them and designates the major fields among which the awards may be distributed. One purpose of these awards is to assist able graduate students who certify their interest in college or university teaching to obtain their doctorates, thus increasing the higher education teaching staff nationally. The program also aims to increase the development and utilization of doctoral degree training facilities and promote their wider distribution geographically.

Two-thirds of these fellowships in an institution must be awarded to students with no more than one-half year of graduate study by September; the remainder may be awarded to those who have completed no more than two years of graduate study by

September. These awards compare favorably with the best fellowships available. The University had 215 students studying under these fellowships in thirty-six different fields of the arts and sciences in 1967-68.

No institution knows until the fall of each year whether it will have any additional fellowships under this program for the following year. A senior or an interested graduate student should inquire from the head of his actual or anticipated graduate major department. Applications will be made directly to the departments or graduate deans of institutions having programs in the desired field. Most institutions have application deadlines from February 15 to 20. Approximately 6,000 of these fellowships were awarded for 1967-68.

National Defense Modern Foreign Language Fellowships—Under Title VI of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States, and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

Late in the fall the Commissioner of Education announces the institutions, the quotas of fellowships, and the specific language and area programs to which the fellowships are allocated. (For 1967 the announcement was made December 1, 1966.)

In 1967-68 the University had a few in Russian language and area studies for majors in Slavic languages only. A few may be available for 1968-69 in the Eastern European area program for students majoring in Russian and also for those majoring in economics, geography, history, or political science, with emphasis on Eastern Europe but also studying a Slavic language. Write to the head of the department of one of these four departments or to the head of the Department of Slavic Languages.

Approximately 1,800 were awarded for 1967-68.

National Science Foundation Graduate Fellowships—The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials and available in the biological, engineering, mathematical, and physical sciences; anthropology; economics (excluding business administration); geography; history and philosophy of science; political science; psychology (excluding clinical); and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, meteorology, and physiology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N. W., Washington, D. C. 20418, which has charge of evaluating applicants for the Foundation. About 1,500 new awards were made for 1967-68. The application deadline for 1968-69 was December 8, 1967.

National Science Foundation Graduate Traineeships—This program was expanded in 1966-67 to include all the areas supported by the Graduate Fellowship Program mentioned above. The National Science Foundation awards training grants to various recognized universities to accelerate the output of graduate students in these fields and to help meet the Nation's future needs for scientific and professional manpower. These grants permit a university to award a specified number of traineeships, 80 per cent of which must go to first-year graduate students. These awards compare favorably with the best fellowships. In 1967-68 the University had eighty-one of these traineeships distributed through thirty-two areas supported by NSF. More will probably be available in many of the areas for 1968-69. No institution will know

until the middle of January whether it will have any available. An applicant should write to the graduate dean at the institution of his choice, or to the head of the department in his graduate field. About 2,100 new awards were made for 1967-68.

National Science Foundation Science Faculty Fellowships—These awards are made to enhance the effectiveness of college faculty members who have at least three years' experience as full-time staff members teaching science, mathematics, or engineering mainly to undergraduates. They are awarded to those working for a Ph.D., or to those holding the degree and teaching in any of the fields supported by the NSF Graduate Fellowship Program. Tenure may be from three to fifteen months and can be spread over three successive summers. For information, write to the National Science Foundation, Washington, D. C. 20550. The application deadline for 1968-69 was October 9, 1967; about 275 awards were made.

U. S. Public Health Service Predoctoral Fellowships—Available to graduate students in anatomy, anthropology, behavioral sciences, biochemistry, biomedical engineering, biophysical sciences, biostatistics, botany, developmental biology, endocrinology, entomology, genetics, history of life sciences, medicinal chemistry, microbiology, nursing, nutrition, organic chemistry, pathology, pharmacology, physiology, social and psychological sciences, zoology, and air and water pollution. These fellowships are used at the university of one's choice and are more frequently awarded to second- or third-year graduate students. Prior to formal application a senior must have been admitted to a graduate school and have obtained a sponsor there who will supervise his training. Application should be made to the Career Development Review Branch, Division of Research Grants, National Institutes of Health, Bethesda, Maryland 20014, by October 1 for awards announced in February, by January 2 for June awards, and by April 1 for September awards. Approximately 2,000 were awarded for 1967-68.

Woodrow Wilson National Fellowships—Awarded by the Woodrow Wilson National Fellowship Foundation for first-year graduate study at the institution of one's choice to outstanding students who show a clear preference for a career in college teaching, especially in the areas of the humanities and social sciences. Science and mathematics majors will be considered; but they must also apply for National Science Foundation Fellowships, and, if one is received, the applicant must accept it in preference to the Woodrow Wilson award. Each student must be nominated by a professor in his undergraduate college. The nomination is sent to the regional representative of the Woodrow Wilson Fellowships for the area in which that college is located. An interested student should consult the dean or other official of his college, or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J. Nominations must reach the regional chairman by October 31 each year.

Instead of the 1,000 awards formerly made annually, only 100 awards will be made for 1968-69, selected from a Designate List of the top 1,000 applicants. The list of Designates will be sent to ten leading graduate schools to which the Ford Foundation is distributing over 41 million dollars for the next seven years to enable these institutions to support a certain number of graduate students throughout their complete doctoral programs, not just for one year. This prestige list of applicants will also be sent to all graduate schools which offer the Ph.D. in the humanities and social sciences. Those not accepted by the above schools will constitute a list of outstanding applicants for other graduate schools to consider.

Woodrow Wilson Dissertation Fellowship Program for 1967-68—A recent grant from the Ford Foundation will enable the Woodrow Wilson Foundation to conduct a new dissertation fellowship program for 1967-68, and two additional years, in the humanities and social sciences. Approximately 200 fellowships will be awarded per year to graduate students nominated by their graduate deans who expect to complete all requirements for the Ph.D. degree, including the dissertation, not later than *four and one-quarter years after beginning graduate study.* Nominations may be sent

in by all graduate schools offering the Ph.D. in the United States and Canada. (Candidates do not have to be former Woodrow Wilson Fellows as was true in former years.)

The fellowship will provide a stipend of $200 per month for up to fifteen months, with a possible supplementary allowance not to exceed $1,000. Cooperating graduate schools will be asked to waive tuition and required fees for these Dissertation Fellows. Nominations will be accepted from graduate deans up to October 15, 1967, of students able to begin full-time dissertation preparation between January and May 1968; and up to January 6, 1968, of students able to begin dissertation preparation between June and December 1968.

Selection of candidates will be made by subject matter committees of established scholars, giving preference to applicants who (a) expect to enter the teaching profession immediately after receiving the doctorate, (b) have started a reasonable and significant dissertation topic early in their graduate studies, and (c) have undertaken a preliminary investigation of the topic by the time of nomination and whose dissertation gives promise of completion within the proposed time schedule.

If you feel that you might be eligible, consult your adviser or department head.

OTHER AIDS

COUNSELORSHIPS FOR MEN—A number of appointments are available to men graduate students to serve as Resident Counselors in the undergraduate residence halls for men. A counselor's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training and experience in personnel work are desirable, though not essential.

These appointments are for three terms (fall, winter, and spring). Remuneration is in the form of room, board, and exemption from the additional out-of-state tuition, if applicable. In addition, a grant-in-aid for full tuition is available to a limited number of the Resident Counselors selected. A counselor may not hold a fellowship or assistantship during the term of his appointment as a counselor, nor may he engage in any other form of part-time employment. He may carry 7 to 9 credits per term.

Requests for information and application forms should be addressed to the Dean of Men, 117 Old Main.

SENIOR RESIDENT POSITIONS FOR WOMEN—Full-time salaried appointments as Senior Residents in undergraduate halls for women are available to qualified women graduate students. Responsibilities include working with student groups in a programming capacity, counseling, and supervising the residence hall during the evening. Preference is given to persons working for a master's degree in higher education, specializing in student personnel administration.

These positions permit the holders to take 4 graduate credits per term at reduced tuition. Appointments are made for the fall, winter, and spring terms. Special arrangements of hours of work and credits may be made for the summer term. It is thus possible to complete work for a master's degree in two calendar years.

Requests for information and application forms should be addressed to the Dean of Women, 111 Old Main.

GRADUATE GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on the basis of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed ten hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $150 per term, to non-Pennsylvanians, $350 per term. A few grants are available for students beginning graduate study in the winter or spring term, if applications are filed six weeks before registration for that term.

Applications should be addressed to the Dean of the Graduate School and must be received by March 15 to be considered for the following summer or fall.

DU PONT TEACHING AWARD IN CHEMISTRY—To be eligible for the E. I. du Pont de Nemours and Company Postgraduate Teaching Assistant Award, a graduate student must be currently serving as a part-time teaching assistant and preferably should have had two years of experience in this capacity. The recipient receives $1,200 in addition to the regular stipend paid him as a teaching assistant.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP—Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is $1,800 for a tenure of three terms plus a grant-in-aid for tuition.

JOHN W. WHITE FELLOWSHIPS—Awarded to two or three graduates of The Pennsylvania State University each year on the basis of scholarship, need, character, and aptitude. The recipients may enroll in any approved college or university. Application is made to the Office of Student Aid, 121 Grange Building.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded annually through individual departments. A request for information should be directed to the department head in the field of the student's major interest.

A.A.U.W. SCHOLARSHIP—The State College Chapter of the American Association of University Women has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

LOANS ADMINISTERED BY THE UNIVERSITY—The Director of the Office of Student Aid has charge of all loans administered by the University, for both undergraduate and graduate students. Application forms may be obtained from his office in 121 Grange Building. Funds are available from three sources:

University Loan Funds have been established through the generosity of University organizations, alumni, faculty, staff, and friends. Graduate students without assistantships who are registered for a full credit load may obtain long-term loans, while graduate assistants who are classified as full-time students by the Dean of the Graduate School may qualify only for short-term loans from these funds. Applicants must demonstrate a need for financial assistance in meeting University-related expenses and be United States citizens, except that international students may qualify for short-term loans if they can secure a responsible resident of Pennsylvania as cosigner of the note. The interest on long-term loans does not begin until after graduation and generally is at a low rate for the first two years.

National Defense Education Act Loan Funds are available for United States citizens from the federal government, this act having been expanded in the fall of 1964, to increase the amount allotted to each institution and to increase the ceiling on loans to graduate students to $2,500 per year. The forgiveness of half the loan over a five-year period for those entering teaching has been extended to college teaching and to teaching in private elementary and secondary schools, as well as to teaching in public elementary and secondary schools. Interest at 3 per cent does not start until nine months after the borrower ceases to be a full-time student. Repayment must then be made at the rate of no less than $15 per month.

The Alumni Graduate Student Loan Fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School alumni who

have received their bachelor's degrees elsewhere. The Graduate Student Association has also made sizable contributions to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and microfilming fee, job interview travel, etc. Students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

STATE HIGHER EDUCATION LOAN PLANS—A number of states have passed laws which enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in those states to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for those who have been residents of Pennsylvania for one year prior to filing an application and are accepted for enrollment in an approved institution of higher education. A full-time graduate student may borrow up to $1,000 per year, the total not to exceed $7,500 during the entire period of his post-secondary education. To be eligible, a part-time graduate student must be enrolled for at least 6 credits and is limited to $500 per year. The federal government will generally pay the interest on behalf of the student while he/she is enrolled in school and the first 3 per cent of interest while the student is making repayment following graduation or withdrawal from school. Repayment of the principal of the loan is not required until the student leaves or graduates from school. Generally, to be eligible for the interest subsidy, the annual adjusted family income must be below $15,000 per year and the student must be enrolled in an eligible course of study in a non-profit institution. A list of participating lending institutions is available from all secondary school counselors, school financial aid officers, or the Pennsylvania Higher Education Assistance Agency, Guarantee Loan Program, Towne House, Harrisburg, Pennsylvania 17102.

Residents of other states should inquire of their state education departments regarding the existence of similar plans. Practically all the states of the United States, and the District of Columbia, have such programs.

ASSURED EDUCATION PLAN—The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his 68th and 61st birthdays, respectively. Payments are handled through the Girard Trust Bank, Philadelphia, Pa. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly.

A student who holds a graduate assistantship, fellowship, or traineeship may not accept employment, either at the University or elsewhere, during the period of his appointment, except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs.

The Office of Student Aid, 121 Grange Building, offers assistance to students in finding part-time employment in town as well as on the campus.

VETERANS BENEFITS—The Coordinator of Veterans Affairs has the responsibility

of handling all applications for benefits under the various Public Laws.

Under P. L. 89-358, a student is classified as full-time if he registers for 8 or more credits, or if he holds a half-time or quarter-time graduate assistantship.

Recently discharged servicemen not in this area may obtain information on veterans' educational benefits under P. L. 89-358 and its recent revision from the Veterans Administration representatives at their local county courthouses.

STUDENT SERVICES

HEALTH CENTER—The services at the Ritenour Health Center are available to graduate students registered for 8 or more credits and to all graduate assistants, fellows, and other holders of graduate tuition grants.

Hospitalized students will be charged $10.00 per day during confinement. A nominal charge will be made for all drugs dispensed to hospitalized or dispensary patients. Consult the *Manual for Graduate Students* for details concerning facilities and services.

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY—The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general educational work of the University.

Therefore any student who desires insurance protection while in attendance at the University (1) against personal injury and/or (2) against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

HEALTH INSURANCE PLAN—A voluntary Accident and Sickness Insurance Plan with a variety of benefits is available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center. For further information, call the local representative for the student insurance carrier (telephone Area Code 814, 238-6725), or write to Graduate Student Health Insurance Plan, Graduate School Office, 101 Willard Building, University Park, Pa. 16802.

PLACEMENT SERVICE—The University Placement Service, in cooperation with all the Colleges and departments of the University, assists both graduate and undergraduate students in finding appropriate employment upon graduation. In addition, services are extended to alumni. Several services are offered: (1) career counseling concerning career planning, career opportunities, employer characteristics, and employment trends; (2) a library of information about employers, employment trends, and career opportunities; (3) the scheduling of interviews with employers visiting the campus; (4) an extended file of employment opportunities for which a student may apply by mail; (5) a listing of summer jobs and internships appropriate to the student's career interests; and (6) conducting of appropriate research. These services are closely coordinated with the Division of Counseling.

Contact is maintained with several thousand employers in education, industry, and government. Information concerning employment opportunities is routinely distributed to all academic departments.

The general placement section concentrates on employment possibilities in industry and government. The teacher placement section concentrates on administrative, teaching, and service opportunities in universities as well as in elementary and secondary schools.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths

serve the student body. Many other religious organizations, including denominational and interdenominational groups, are active on the campus and in association with local churches.

STUDENT AFFAIRS—The Graduate Student Association is the official University-wide organization of graduate students. All students have membership in the Association, which promotes the general welfare and the academic interests of graduate students. It publishes the *Graduate School Newsletter,* helps to sponsor the Graduate School lecture series, and sponsors social functions.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees: academic and professional. Of the eleven master's degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forestry, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE POINT AVERAGE—A minimum grade point average of 3.00 for work done at this university is required for graduation in the case of all candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION—In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the field in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of field and can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. An applicant who meets the minimum grade point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the minimum period of residence. An applicant for admission to the M.Ed. program in most major fields is required to have had at least 18 credits in education and related psychology, and in certain major fields may be required to have had practice teaching.

After a student has been admitted to a degree program, he should confer with the head of his major department concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department.

TRANSFER CREDIT—Subject to the limitations given below on the use of credits earned away from the University Park Campus, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. When transfer credits are accepted at the time of admission, the student is not really assured of their applicability in his program until he has consulted his adviser and the details of his graduate program have been worked out.

M.A. and M.S.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 12 must be in 500 on the University Park Campus. A candidate must present a major and either a minor field of study or an approved group of general studies. A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to but different from that of the major. A general studies group consists of no fewer than 6 credits in fields other than that designated as the major field and considered by the major department to have significance and value for the candidate.

The major department or the committee in charge of the major field is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in its field, examining the candidate in the area of studies he has undertaken in its field, and certifying that the minor requirements have or have not been met.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major field. A thesis is required of all candidates for the degree of Master of Science and of many candidates for the degree of Master of Arts. Details are given in the introductory paragraphs under the major field headings in the latter part of this bulletin. If a student is required to write a thesis, he must complete at least 6 credits of thesis research (600 or 610).

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The department may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off-campus. To do so he must make satisfactory arrangements in advance with his adviser and the head of his major department.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

M.Adm.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Administration are designed to meet the professional needs of practicing and potential administrators. A basic premise is that administration is a necessary function of all organizations and that it embodies a common body of knowledge and skills regardless of its area of application. These programs should be sharply distinguished from the research-oriented programs which lead to the academic degree of Master of Science in such majors as business administration, educational administration, and others.

The programs require a minimum of 30 graduate credits, at least 18 in core courses and 12 in the area of specialization, with the greater portion of the courses being at the 500 level.

Each student is required to complete a research project in the field or a laboratory in which he applies research methods and tests his solution through experimentation or simulation. The report must have the quality but need not have the depth of theoretical development of a graduate thesis.

After substantially completing his course requirements, a candidate must pass a comprehensive written and oral examination to be administered by a committee composed of graduate faculty members. The candidate will be expected to demonstrate his ability to integrate the knowledge gained in specialized areas with that gained in the broad general area of administration.

M.Agr.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Agriculture have a professional orientation and provide training for increased competence in the various fields of agriculture. They should be clearly distinguished from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which at least 12 must be in 500 level courses and the remainder in 400 level courses. A minimum of 20 credits must be earned on the University Park Campus, and at least 12 must be earned outside the candidate's major field.

In addition to credit requirements, a candidate must present a paper on a selected professional problem comparable in quality to a thesis in which he applies scientific methods to the solution of a problem. He must demonstrate ability to (a) formulate and state meaningfully the problem and objectives, (b) critically analyze the present state of knowledge of the problem, (c) acquire and analyze information to help solve the problem, (d) draw logical conclusions, and (e) interpret the relationship between the findings and professional problems. The paper will be evaluated by a committee appointed by the Dean of the Graduate School.

The candidate is required to pass a final examination administered by a committee of three faculty members appointed by the Dean of the Graduate School. At least one member of the committee must come from a department other than that of the candidate's major field.

M.B.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Business Administration are designed to develop advanced professional competence in the various fields of business administration. They should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Science and Doctor of Philosophy with a major in Business Administration.

The programs require a minimum of 36 graduate credits, of which at least 18 must be at the 500 level and at least 26 earned on the University Park Campus. Candidates who enter this program without undergraduate training in business administration may be required to take up to 30 credits of preparatory courses in addition to the usual graduate requirements.

Each candidate is required to present a project paper comparable in quality and scope of work to a graduate thesis.

After substantially completing his course requirements, a candidate must pass a comprehensive examination, which may be written or oral or both, to be administered by a committee composed of graduate faculty members.

Applicants for the various graduate programs in business administration are required to take the Admission Test for Graduate Study in Business given by the Educational Testing Service.

M.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the several fields of education. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. In most major fields the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20 must be earned on the University Park Campus; at least 24 must be in course work.

At least 15 credits in 500 series courses is required except in those fields for which the Dean has approved the waiving of this requirement for an experimental period of five years.

MAJORS IN THE FIELDS OF EDUCATION—A student may major in one of the approved fields of education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate department of education.

A program of this type requires at least 6 credits to be earned outside the fields of education.

MAJORS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German, may choose such a field as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose such a major as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER—Six credits may be granted for an approved thesis. Those candidates who do not elect to write a thesis are required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall

be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department to require one or more copies of such an essay for its library or other files.

M.Eng.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which at least 12 must be earned in graduate courses (500 series); at least 6 must be earned outside the candidate's field of concentration.

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

M.F.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art, music, or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned on the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Forestry provide training for increased professional competence in the several specialized areas of forest resource management and forest products. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science with a major in forestry.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be

taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.P.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration at local, state, national, and international levels or with private and voluntary agencies. This program should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may also specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required, of which at least 6 must be devoted to either a thesis or an internship. Students with extensive government experience will write a thesis; others will serve an internship and write a critical review of the experience, the review to be comparable in quality to a thesis. A comprehensive final examination will be required of all students, the examination to be written, oral, or both.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervising committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

The degree is a terminal one, and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

M.R.P.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, the maintenance of cultural and aesthetic values, and the legal and governmental techniques for their implementation.

A minimum of 45 graduate credits is required, of which at least 35 must be earned on the University Park Campus. At least 36 credits are required in planning courses, of which 9 will be devoted to a group regional planning project or a problem-oriented thesis. Students who do not submit a thesis will present a project report, comparable in quality and scope to a graduate thesis.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION—A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major field in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted

as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department and is given early in the student's program.

There are no specific admission requirements in education and related psychology for the degree of Doctor of Education unless specified by the department or committee in charge of the particular major field. When such requirements do exist, they are listed in the introductory paragraphs under the major field headings in the latter part of this bulletin.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE POINT AVERAGE—A minimum grade point average of 3.00 for work done at this university is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later.

TIME LIMITATION—A student who was formally accepted as a doctoral candidate on or after June 1, 1963, is required to complete his program within seven years from the date of his acceptance as a candidate. A student who was admitted to doctoral candidacy, formally or informally, prior to June 1, 1963, is required to complete his program before July 1, 1971.

OFF-CAMPUS AND TRANSFER CREDITS—Subject to the approval of his adviser and the head of his major department, a student may register for research to be done away from the University Park Campus. Such work will not be approved simply because the arrangement is convenient for the student; scholarly considerations must determine the choice of location.

With the approval of his committee, a candidate may apply toward the minimum requirements of a doctor's degree a maximum of 10 credits earned in Continuing Education classes or at the Commonwealth Campuses of The Pennsylvania State University. Credits so earned as a part of a master's degree program must be included in the limit of 10.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major field may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major field may be accepted here to apply toward doctoral degree requirements. Work beyond the master's will not be transferred if taken more than five years before beginning work for the doctorate at Penn State. Credits transferred will apply toward meeting degree requirements only if judged by the doctoral committee to be appropriate to the candidate's program of study.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted to a degree program, he should confer with the head of his major department concerning departmental procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major department for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of selected members of the Graduate Faculty. It is appointed by the Dean of the Graduate School, upon recommendation of the head of the major department, after the student is admitted to candidacy. The chairman of the committee must hold senior membership in the Graduate Faculty. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. At his discretion, the Dean may add other members to the committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after his admision to candidacy. The committee will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

LANGUAGE AND COMMUNICATION COMPETENCE—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School and must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet the language and communication requirement which has been established by his major department with the approval of the Graduate School Committee on Languages and Communication Skills.

If a candidate is to be examined for a reading knowledge of a foreign language by one of the language departments, he must report his intention to take the examination to the secretary of the language department during the registration period for the term during which he wishes to take it. The examination will be administered on dates announced in the graduate calendar at the beginning of this bulletin.

Candidates for the D.Ed. degree may be required by their major departments to demonstrate competency in foreign languages, but there is no Graduate School requirement.

COMPREHENSIVE EXAMINATION—When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major and minor fields of study.

A candidate for the Ph.D. must have satisfied the language and communication requirements before taking the examination.

All candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later are required to have a minimum grade point average of 3.00 for work done at this university at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be either written or oral, or both. A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School, and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATIONS—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the Graduate Dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before Commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole field of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

OLD AND NEW REQUIREMENTS—In fall term 1967 a revised set of requirements for the Ph.D. went into effect. A student who, by the end of summer term 1967, had earned 45 or fewer graduate credits which were applicable toward his degree follows the new requirements. A student who had earned more than 45 such credits by that date follows the old regulations or, upon approval of the department or interdisciplinary committee, comes under the new regulations provided the Dean of the Graduate School was notified by the department or committee in writing before January 1, 1968.

OLD RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research, or their equivalent in credits, is required for the Ph.D. degree. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term, and three such terms will meet the minimum residence requirement for the Ph.D.

NEW RESIDENCE REQUIREMENTS—There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered student, during which time he is engaged in full-time academic work on the University Park Campus *and* is certified by his department as de-

voting half time or more to graduate studies and/or thesis research to meet his degree requirements.

After a student has passed the comprehensive examination and met the three-term requirement described in the preceding paragraph, no further registration for credit will be required by the Graduate School. He shall, however, maintain his status as a student by registering continuously (at least three terms per calendar year) until the thesis is accepted by his doctoral committee. This registration may be for courses for credit, for 601, or for 611, the latter two involving no credit and no tuition. In each case, the payment of the special dissertation fee for Ph.D. candidates is required.

CANDIDACY EXAMINATION—This examination is administered by the major department. For students following the old requirements it is to be given near the end of the first, or at the beginning of the second, year of graduate work, including that done for the master's degree and work done elsewhere as well as here (i.e., at about the time he has earned a total of 30 graduate credits). A student transferring from another graduate school with 30 or more transfer credits must take this examination before he has earned more than 10 credits here.

For a student following the new requirements, this examination may be taken after he has earned at least 12 credits in graduate courses beyond the baccalaureate. It should be taken early in his program.

MINOR FIELDS—A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and the minor fields.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis, together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than five weeks prior to the Commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate, e.g., biological science, foods and nutrition, or English.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) the satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) suc-

cessfully passing examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research—or their equivalent in credits—of which at least 30 credits must be earned in residence at the University Park Campus, is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless his major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which he is required to earn on the University Park Campus. The maximum credit load permitted a student who is employed full time is 4 credits per term.

MAJOR AND MINOR FIELDS—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major field of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education.

A candidate choosing a major in one of the fields of education must also choose either a minor or a group of general studies with the approval of the major department. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside the fields of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside the fields of education considered by the major department to have significance and value for the candidate.

COMPREHENSIVE EXAMINATIONS—In addition to demonstrating a high level of competence in the subject matter of his major and minor fields, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later are required to have a minimum grade point average of 3.00, for work done at this university, at the time the comprehensive examination is given.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. The thesis may be based upon a product or project of a professional nature, provided that scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis, together with an abstract, typewritten in triplicate, must be filed in the office of the Dean of the Graduate School not later than five weeks prior to the Commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

PROGRAMS AND COURSES

Programs of study leading to advanced degrees are offered in many major and minor fields. These are listed in the following section, and the major fields are summarized at the beginning of the following section. Related courses are grouped together under the name of the field. To locate a particular course or group of courses, consult the index.

In general, departments of the University are identified with specific major fields. Thus aerospace engineering is a major field of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, engineering acoustics and comparative literature are major fields for which there are no corresponding departments. In such cases a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one field. Thus the Department of Materials Science offers work in ceramic science, fuel science, metallurgy, and solid state science.

Applicants for admission are encouraged to consult the person whose name is listed under the major field heading.

DEGREES—In those major fields approved for the doctorate, the Ph.D. is normally conferred, although a program leading to the D.Ed. may also be arranged with the consent of the department or committee in charge if such a professional program is appropriate. Similarly, in major fields approved for the master's degree the M.A. or M.S. is normally conferred, but a program leading to the M.Adm., M.Agr., M.B.A., M.Ed., M.Eng., M.F.A., M.F., M.P.A., or M.R.P. may also be available. The D.Ed. and M.Ed. are not limited to the fields of education but, with the consent of the department or committee in charge, may be offered in any approved major field appropriate to the preparation of teachers, such as mathematics or English. In this case the program is sponsored by a major department outside the fields of education, such as the Department of Mathematics, but the student's minor is in education.

MINOR FIELDS—All major fields listed are also acceptable as minors, subject to the approval of the proposed minor department. In addition, a few fields in which no advanced degrees are offered have been approved as minors for candidates who are majoring in related areas. Such minor fields are identified in the summary at the beginning of the following section and by a brief statement under the field heading in that section.

A candidate's choice of minor field depends upon the particular degree he is seeking and is subject to the approval of both his major and minor departments. The requirements in each minor field are established by the minor department subject to the regulations of the Graduate Faculty.

INTERDISCIPLINARY MAJORS—In addition to the majors listed on the following pages, interdisciplinary majors involving two or more departments may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental committees.

OTHER FIELDS—Fields which have not been approved for either major or minor work, but in which approved courses are offered, are listed at the end of this bulletin. These courses may be used in graduate programs as electives or as part of a general studies program, subject to the approval of the major department and to the restrictions upon the use of 400 series courses in degree programs.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 59 to 64 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll by the Dean of the Graduate School.

The numbers 601 and 611 do not denote courses but are used for non-credit registration by a Ph.D. candidate who is following the new regulations which went into effect in fall term 1967. Registration under these numbers will maintain his status as a student during the interval which begins at the time he has both passed the comprehensive examination and met the three-term, full-time academic requirement and ends at the time his doctoral committee accepts the thesis. The student will register for 601 if he will be using University facilities and/or faculty services, whereas he will register for 611 if he will be off-campus and requiring little or no faculty service.

CREDITS—A credit is defined as a unit of time approximately equivalent to one week of full-time graduate study. Accordingly, a full-time student having no concurrent employment may earn a maximum of 10 credits in a ten-week term. A "credit" as used in this bulletin, therefore, is identical in meaning with a "semester credit" and should not be confused with a "quarter credit," which is associated with the traditional quarter system. By increasing the length of class periods to 75 minutes, the Penn State calendar based upon a ten-week term provides for the same amount of time in a given course as does the typical semester plan.

COURSE DESCRIPTIONS—A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department offering the course.

A department may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400 and 500 series courses a department may schedule an individual student for fewer credits than the maximum number but in no case for more than the maximum number authorized.

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes,* which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

RESEARCH AND THESIS WORK—In registering for thesis work a student uses the appropriate number (600, 601, 610, or 611) preceded by the abbreviation designating his major field. Thus, ENGL 600 denotes thesis research in English being done on

the University Park Campus and ENGL 610 thesis research in English being done off-campus.

The numbers 601 and 611 are available only to Ph.D. candidates who are following the new regulations, have passed the comprehensive examination, and have met the three-term, full-time academic requirement. Such a candidate in engineering mechanics will register for E MCH 601 if he will be using University facilities and/or faculty services or for E MCH 611 if he will be off-campus and requiring little or no faculty service.

It should be assumed that 600 and 610 are available in all graduate major fields and that 601 and 611 are available in all fields approved for the Ph.D., although these numbers may not always appear in the *Schedule of Classes* for each term.

Major and Minor Fields

GRADUATE FIELDS OF STUDY

Administration—M.Adm.
Aerospace Engineering—Ph.D., M.S.
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—M.S.
Agronomy—Ph.D., M.S., M.Agr.
Animal Industry—Ph.D., M.S., M.Agr.
Animal Nutrition—Ph.D., M.S.
Anthropology—Ph.D., M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A., M.F.A.
Art Education—Ph.D., D.Ed., M.S., M.Ed.
Art History—Ph.D., M.A.
Astronomy—Ph.D., M.S.
Biochemistry—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Business Education—Ph.D., D.Ed., M.S., M.Ed.
Ceramic Science—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S.
Chemistry—Ph.D., M.S.
Child Development and Family Relationships—Ph.D., D.Ed., M.S., M.Ed.
Civil Engineering—Ph.D., M.S., M.Eng.
Clothing and Textiles—Ph.D., D.Ed., M.S., M.Ed.
Comparative Literature—Ph.D., M.A.
Computer Science—Ph.D., M.S.
Counselor Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Earth Sciences—M.Ed.
Economics—Ph.D., M.A.
Education of Exceptional Children—Ph.D., D.Ed., M.S., M.Ed.
Educational Administration—Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology—Ph.D., M.S.
Electrical Engineering—Ph.D., M.S., M.Eng.*
Elementary Education—Ph.D., D.Ed., M.S., M.Ed.
Engineering Acoustics—Ph.D., M.S.
Engineering Mechanics—Ph.D., M.S., M.Eng.
Engineering Science—M.Eng.*
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S., M.Agr.
Extension Education—M.Agr., M.Ed.
Family Economics and Home Management—Ph.D., D.Ed., M.S., M.Ed.
Food Service and Housing Administration—M.S., M.Ed.
Foods and Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Forestry—Ph.D., M.S., M.F.
French—Ph.D., M.A.
Fuel Science—Ph.D., M.S.
General Engineering—M.Ed., M.Eng.
General Family Studies—M.S., M.Ed.
Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed., M.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Art (minor only)
Home Economics Education—Ph.D., D.Ed., M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—Ph.D., M.S., M.Eng.
Journalism—M.A.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Preparation—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S.
Music—M.A., M.F.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
Physiology—Ph.D., M.S.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., D.Ed., M.S.
Public Administration—M.P.A.
Recreation and Parks—M.S., M.Ed.
Regional Planning—M.R.P.
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
School Psychology—D.Ed., M.S., M.Ed.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
Solid State Science—Ph.D., M.S.
Spanish—Ph.D., D.Ed., M.A., M.Ed.
Speech—Ph.D., D.Ed., M.A., M.Ed.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics—Ph.D., M.A., M.S.
Theatre Arts—M.A., M.F.A.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

The degrees listed above are the ones normally conferred in each of the designated major fields. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above fields in which a master's degree is conferred provided the field is appropriate to the preparation of teachers.

*Not offered on the University Park Campus.

COURSES IN MAJOR AND MINOR FIELDS

ADMINISTRATION

Robert J. McNeill
In Charge of Graduate Programs in Administration at Capitol Campus
P. O. Box 230, Middletown, Pa. 17057

Degree Conferred: M.Adm.

Programs leading to the degree of Master of Administration are offered only at the Capitol Campus near Harrisburg. All candidates take a core program but may concentrate in some area of specialization through elective courses. Emphasis may be placed on business administration, engineering administration, or logistics administration.

Admission requirements include a knowledge of differential and integral calculus, micro- and macroeconomic analysis, and statistical inference.

AEROSPACE ENGINEERING

George F. Wislicenus, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Holl, Lumley, McCormick, and Wislicenus; Associate Professor Sevik; Assistant Professor Tennekes. Associate Members—Assistant Professors Kingsbury, Lakshminarayana, and Payne.

Opportunities are available for graduate study in the following and related areas: modern fluid mechanics and physics, the interaction of fluids with solids, and the application of these disciplines to the design of devices and to the environment in which they operate. These topics are specifically included: cavitation, magnetohydrodynamics, rarified gas dynamics, the stability of laminar motions, turbulence, aero- and hydroelasticity, stability and control of vehicles, turbomachinery, V/STOL aircraft, high lift devices, and ground effect machines.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so.

AEROSPACE ENGINEERING (ARO E)

401a,b,c. Aerospace Engineering Projects (1-12)
402. Aerospace Design (2)
407. Aerodynamics of V/STOL Aircraft (3)
410. Aircraft and Space Propulsion (3)
411. Aeroelasticity (3)
412. Turbulent Flow (3)
413. Stability and Control of Aircraft and Missiles (3)
415. Free Molecular Flow and Radiative Heat Transfer (3-6)

416-417. Aerospace Undergraduate Thesis (2 each)
420. Principles of Flight Testing (3)
421. (M.E. 421) Intermediate Viscous Flow (3)
422. (M.E. 422) Intermediate Inviscid Flow (3)
425. Theory of Flight (3)

503. Electromagnetically and Chemically Active Flows (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. Aerodynamics of V/STOL Aircraft (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aro.E. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Perfect Fluid Theory A (3) Mathematical review, equations of motion and general consequences, application of complex variables to two-dimensional flow, conformal representations, Stokes' stream function.

509. Perfect Fluid Theory B (3) Review of axisymmetric motion; two-dimensional vortex motions; motions with cylindrical, spherical geometry; Bessel, Legendre functions; vortex motions in space. Prerequisite: Aro.E. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory. Prandtl-Meyer flow, method of characteristics.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of clasical flows.

518. Aircraft and Missile Dynamics (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, re-entry, stability and control, and automatic control. Prerequisite: Aro.E. 413.

520. Selected Topics in Aerospace Engineering (1-12)

AGRICULTURAL ECONOMICS

MACKLIN E. JOHN
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members—Professors Barr, Becker, Bennett, Brandow, Butz, Frey, Hutton, McAlexander, Pasto, Pierce, Stemberger, and Trotter; Asosciate Professor Partenheimer. Associate Members—Assistant Professors Gamble, Hallberg, Herrmann, Holt, Jansma, and Schutjer.

The graduate program emphasizes economic theory and analytical techniques in conjunction with concentration in farm management, production economics, agricultural marketing, resource economics, agricultural policy and prices, or international agricultural trade and development.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

AGRICULTURAL ECONOMICS (AG EC)

407. ADVANCED FARM MANAGEMENT (3)
410. AGRICULTURAL FINANCE AND APPRAISAL (3)
420. AGRICULTURAL PRICES (3) *Mr. Bennett*
421. LAND ECONOMICS (3) *Messrs. Frey and Gamble*
422. LAND AND WATER RESOURCE POLICY (3) *Mr. Jansma*
450. INTERNATIONAL AGRICULTURAL TRADE AND DEVELOPMENT (3) *Mr. Schutjer*
460. INDUSTRIAL ORGANIZATION IN FOOD PROCESSING AND DISTRIBUTION (3) *Mr. Brandow*
461. DECISION-MAKING IN AGRICULTURAL MARKETING FIRMS (3) *Mr. Stemberger*

500. SEMINAR IN AGRICULTURAL ECONOMICS (1-6) Review of current literature and problems.

504. SEMINAR IN AGRICULTURAL POLICY (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy-making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Mr. Brandow*

505. ADVANCED AGRICULTURAL STATISTICS (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. SEMINAR IN FARM MANAGEMENT (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

514. SURVEY RESEARCH TECHNIQUES IN AGRICULTURAL ECONOMICS (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years.

515. ECONOMIC PROBLEMS IN THE MARKETING OF DAIRY PRODUCTS (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Even years. *Mr. Hallberg*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences. *Mr. John*

527. Seminar in Applied Quantitative Methods (1-4)

534. Agricultural Production Economics (3) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change.

535. Seminar in Agricultural Marketing (2)

541. Economic Organization of Agriculture (3) Agriculture as a sector of the total economy; changes in markets, resources, internal structure, and income; interregional competition.

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods. *Mr. Herrmann*

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use. *Mr. Jansma*

AGRICULTURAL EDUCATION

David R. McClay, *Head of the Department*
101 Agricultural Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors McClay and Stevens. Associate Members—Associate Professors Anthony and Hoover.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, business, or in general studies. Programs may include courses needed for certification in other fields of education.

AGRICULTURAL EDUCATION (AG ED)

418v. Survey of Vocational Education in Agriculture (1-4)
420v. Instructional Media in Agriculture (1-6)
422v. Supervision of Vocational Education in Agriculture (1-4)
424v. Occupational Guidance in Agricultural Industry (1-4)
426v. Adult Education in Agriculture (1-4)
434v. Agricultural Developments (1-6)

501v. Agricultural Education in the United States (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. Teaching Agriculture (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation.

504v. Agricultural Education Seminar (1 per term)

508v. Administration and Supervision of Agricultural Education (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. Teacher Education in Agriculture (1-6) Organization and administration of university programs of teacher education in agriculture, including pre-service preparation, continuing education, research, and other services.

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. Program Development in Agricultural Education (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, technique of teaching, and measurements of results of teaching.

AGRICULTURAL ENGINEERING

Frank W. Peikert, *Head of the Department*
204 Agricultural Engineering Building

Degree Conferred: M.S.

Graduate Faculty: Senior Members—Professors Mohsenin and Peikert. Associate Members—Professors Aldrich, Bartlett, and Stephenson; Associate Professors Kjelgaard and Schroeder.

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; rural sanitation and conservation engineering; and computer technology applied to agricultural engineering problems.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, solar poultry houses and plant growth structures for modified atmosphere, a general purpose analog computer, and a laboratory for research on mechanical and rheological properties of agricultural materials. This laboratory is equipped with an Instron testing machine, complete with environmental chamber for research on the rheology of foods and agricultural materials. It also con-

tains a polaroscope and acoustical instrumentation with which mechanical properties of agricultural materials can be studied using photoelastic stress analysis and sonic techniques.

Prerequisite to major work is the completion of an undergraduate major in engineering.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Agricultural Structures (3)
404. Agricultural Machinery (3)
405. Agricultural Process Engineering (3)
406. Advanced Dairy Engineering (3)
407. Soil Water Engineering (3)
408. Instrumentation for Agricultural Production and Processing (3)
409. Agricultural Systems Engineering (3)
410. Agricultural Power (3)
420. Seminar (1)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY

Walter I. Thomas, *Head of the Department*
118 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members—Professors Duich, Fortmann, Hunter, Kardos, Matelski, Richer, Robinson, Thomas, and Washko; Associate Professors Baker, Cleveland, McKee, and Starling. Associate Members—Professor Raleigh; Associate Professors Harrington, L. J. Johnson, M. W. Johnson, Marriott, Marshall, and Pfeifer; Assistant Professors Cunningham, Hill, and Waddington.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

AGRONOMY (AGRO)

411. Breeding of Fields Crops (3) *Mr. Johnson*
416a. Soil Characterization and Classification—Lecture (4) *Mr. Petersen*
416b. Soil Characterization and Classification—Practicum (1) *Mr. Petersen*
417. Forest Soils (3) *Mr. Pennock*
419. Soil Properties (4) *Mr. Baker*
422. Soil Conservation (3) *Mr. Cunningham*
423. Pasture and Grassland Management (3) *Mr. Washko*
424. Fertilizer Technology (3) *Mr. Marriott*
425. Principles of Field Crop Production (3) *Mr. Pfeifer*
431. Soil Fertility and Management (3) *Mr. Marriott*
438. Principles of Weed Control (3) *Mr. Raleigh*
490. Agronomic Problems (1-6) *Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Bot. 441. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Phys. 215, Bioch. 425. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Bot. 422. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Bot. 422. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques;

combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. *Mr. Starling*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Bot. 441. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Bot. 441. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 419, G.Sc. 23. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1 per term)

ANIMAL INDUSTRY

Thomas B. King
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members—Professor Bortree; Associate Professor Gobble. Associate Members—Professor King; Associate Professors Sherritt, Sink, and Wilson.

A student may specialize in animal production and management, animal breeding, or meats. For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

ANIMAL INDUSTRY (A I)

400. Special Topics (1-6)
405. Meat Animal Management (4)
421. Science of Meat (3)
423. Advanced Livestock Selection (2)
424. Animal Industry Seminar (1)
431. Advanced Meat Selection and Grading (2)

*Credits 1-6 per term.

500. Seminar in Animal Industry (1-6)

501. Pedigree Study (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. Research in Meats (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

503. Problems in the Animal Industry (1-6) Literature review, research methods, and current research in problems relating to the animal industry.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

ANIMAL NUTRITION

Thomas B. King
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Barron, Baumgardt, Bratzler, and Hartsook; Associate Professor Hershberger. Associate Members—Professors Cowan and King; Associate Professor Long.

The graduate program emphasizes nutrition, including energy metabolism, physiology of nutrition, and growth. For admission without deficiencies an applicant should have had at least one year's work each in general chemistry, organic chemistry, and physics; 3 credits in analytical chemistry; 3 credits in biochemistry; mathematics through integral calculus; and 9 credits in biology.

ANIMAL NUTRITION (A NTR)

401. Physiology of Nutrition (3)
402. Energy and Protein Metabolism (3)

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY

Donald P. Kent
Head of the Department of Sociology and Anthropology
237 Temporary Office Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Baker, Carpenter, F. R. Matson, Mook, and Sanders. Associate Member—Assistant Professor Nydegger.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: new world archaeology, middle eastern archaeology, archaeological methodology, physical anthropology with special emphasis on human ecology, cultural ecology, comparative economics, personality and culture, oceanic ethnology, Latin American ethnology, folk and peasant society.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit.

A thesis is required of all M.A. candidates in this field.

The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

ANTHROPOLOGY (ANTHY)

400. Human Evolution: the Material Evidence (3)
401. Human Evolution: Theory and Process (3)
402. Human Ecology (3)
403. Applied Physical Anthropology (3)
405. Primatology (3)
420. Archaeology of the Near East (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
440. Ethnology of South America (3)
443. Ethnology of the Old World (3-6)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
447. Ethnology of Sub-Saharan Africa (3)
449. Ethnology of Southeast Asia (3)
450. Comparative Social Organization (3)
451. Economic Anthropology (3)
453. (Soc. 453) Primitive Religion (3)
455. Culture and Personality (3)
456. Cultural Ecology (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)
462. Methods in Archaeology (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Applied Anthropology (3) Methods and results of studies in which anthropological theory was applied to current problems in human biology and culture.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

506. Cultural Dynamics (3) Survey of the major theories of culture change with special reference to archaeological research.

507. The Biology of Human Adaptability (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.

508. Research Problems in Culture History (3)

509. Seminar in Regional Studies (3-6) Research and analysis in selected world cultural areas, including ecology, pre-history, history, ethnography, and current status.

530. Individual Readings in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

531. Individual Research in Anthropology (3-6)

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-9) Individual field work in any aspect of anthropology, supervised by staff of professorial rank.

562. Laboratory Methods in Anthropology (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

ARCHITECTURAL ENGINEERING

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty: Senior Member—Professor Richardson. Associate Members—Associate Professor Albright; Assistant Professor Knott.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirements for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)
430. Architectural Engineering (3)

431. Architectural Engineering (3)
432. Architectural Engineering (4)
433. Architectural Engineering Thesis (2)
434. Architectural Engineering Thesis (2)
435. Architectural Engineering Thesis (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)
464. Advanced Architectural Illumination Systems Design (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.
Mr. Richardson and Staff

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar. *Mr. Richardson and Staff*

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE

Gregory Ain, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.

Graduate Faculty: Senior Member—Professor Ain. Associate Member—Professor Hallock.

For admission, a degree of Bachelor of Architecture, Bachelor of Science in Architecture, or Bachelor of Fine Arts in a five-year curriculum in architecture is required.

ARCHITECTURE (ARCH)

415. City Planning (3)
416. City Planning (3)
443. Architectural Design Analysis (3)

501. Architectural Design (4-8) Problems in advanced planning and design, including study of group composition. Practicum and seminar.

502. Architectural Research (2-12) Prosecution of assigned problems under the guidance of an instructor.

ART

Wirth V. McCoy, *Head of the Department*
210 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Member—Professor Heller. Associate Members—Professors Altman, Fraenkel, McCoy, and Zoretich; Associate Professors Adams, Cook, Frost, Montenegro, and Shobaken.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio, photographs, or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

ART (ART)

411. Seminar in Art (3)
*425. Advanced Drawing (3)
*430. Advanced Sculpture (3)
*448. Advanced Printmaking (3)
*450. Advanced Painting (3)
460. Advanced Watercolor (3)
470. Graphic Design II (3)
471. Graphic Design III (3)
472. Exhibition Concepts and Structure (3)
473. Seminar in Design Research (3)
*480. Advanced Ceramics (3)
495. Advanced Photography (3)

501. Art Research (2-6) Original study and practice in art relating to material, concept, or technique.

530. Advanced Sculpture (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. Printmaking (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

*May be repeated for a total of 12 credits.

550. Painting (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. Design (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

580. Ceramics (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

ART EDUCATION

Edward L. Mattil, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Beittel and Mattil; Associate Professor Edmonston. Associate Members—Associate Professors Chomicky, Frankston, and Schwartz.

Graduate programs in this field prepare students for careers in public school art teaching, art supervision, college teaching, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree.

ART EDUCATION (A ED)

404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concepts derived from related disciplines; the examination of current problems; current literature.

504. Advanced Methods in Graphic Processes (3) Exploration through laboratory experience of printing method: etching, silk screen, linoleum, or other; applications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material design and purpose in crafts discussed by means of outstanding products of different materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design and 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensional processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing, and firing processes as related to aesthetic considerations in contemporary art forms and past cultures. Prerequisite: A.Ed. 420.

534. Creative Art Activity for the Handicapped (3) Specific methods for development of creative art activity with the physically, mentally, emotionally, and socially handicapped; adjustive effect upon them. Prerequisite: 6 credits in art education or 6 in special education or 6 in psychology.

535. Administration and Supervision of Art Education Programs (3) The problems and responsibilities of the city, county, and state art supervisor; curriculum, facilities, financing, supervision, in-service training, and reporting. Prerequisites: A.Ed. 435, 436.

588. History of Art Education (3) Historical development of philosophies in art education in the United States and abroad.

598. Research Methods in Art Education (3-6) Orientation in research methods; findings and designs related to the study of problems in art education.

599. Research in Art Education (1-6) Independent research, under an adviser, to be terminated by a scholarly report proportionately comparable in quality to a master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 level, including A.Ed. 598.

ART HISTORY

Winston R. Weisman, *Head of the Department*
229 Arts Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Battisti, Enggass, Hyslop, and Weisman. Associate Member—Assistant Professor Mauner.

Graduate work is offered in the following areas: modern, Renaissance and Baroque, medieval, ancient. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

For admission a minimum of 18 credits in art history is required. Lacking these, a promising candidate may be accepted on condition that he make up the deficiency without graduate degree credit. Candidates for the M.A. are required to complete a master's thesis and to demonstrate a reading knowledge of at least one foreign language. Candidates for the Ph.D., upon completion of course work and before beginning the thesis, must pass a written comprehensive examination. They must also demonstrate a reading knowledge of two foreign languages. The department normally requires that the student take German and either French or Italian. Other languages may be substituted with the approval of the adviser.

ART HISTORY (ART H)

400. Studies in Art History (3-6 per term)
401. Studies in Greek Art (3)
402. The Illuminated Manuscript (3)

405. Pioneers of Modern Architecture (3-6)
410. Taste and Criticism in Art (3)
411. Art of Imperial Rome (3)
412. The Gothic Cathedral (3)
414. Studies in Italian Baroque Art (3-9)
415. The Skyscraper (3)
416. American Painting: 1876-1913 (3)
422. Studies in Medieval Sculpture (3)
423. Studies in Italian Renaissance Art (3-9)
424. Masters of Northern Baroque Art (3)
425. Movements in 19th Century Art (3)
435. Movements in 20th Century Art (3-6)

510. Art History Research (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. Seminar in Ancient Art (3-12) Selected topics from the history of Greek and Roman art.

512. Seminar in Medieval Art (3-12) Original research into problems dealing with the art of the Middle Ages.

513. Seminar in Renaissance Art (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. Seminar in Baroque Art (3-12) Investigations in the area of Baroque art centering around major masters and monuments.

515. Seminar in Modern Art (3-12) Lectures, readings, reports, and discussions in the field of modern art.

525. Seminar in Modern Architecture (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

ASTRONOMY

John P. Hagen, *Head of the Department*
103 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professor Hagen; Associate Professor Sampson. Associate Members—Associate Professors Bauer and Zabriskie; Assistant Professor Winkler.

Opportunities are available to prepare for research or teaching. The principal research facilities of the department are in radio astronomy, but work can be done in meteors, astrophysics, and in various phases of theoretical astronomy. Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy.

A bachelor's degree in astronomy, physics, mathematics, or related branches of engineering is required for admission. Opportunity to make up possible undergraduate deficiencies is provided.

ASTRONOMY (ASTRO)

430. General Astronomy for Teachers (3)
470. Solar Physics (3)
490-491. Introduction to Astrophysics (3 each)
492. Space Astronomy (3)
495. Practical Astronomy (3)

510. Astrophysics (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. Astrophysics (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. Astrophysics (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussions of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

520. Galactic Structure (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

522. Spherical Astronomy (3) Astronomical coordinate systems, Kepler's equation, aberration, parallax, precession and nutation, time, eclipses and occultations, and solar motion.

525. Double Stars (3) Two-body theory; analysis of visual, astrometric, spectroscopic, and eclipsing binaries; and discussions of particular systems. Prerequisite: Astro. 522.

582. Radio Astronomy (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. Radio Astronomy (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

590. Special Topics (1-3 per term) Theoretical studies in any field of modern astronomy or astrophysics, with or without associated experimental work. Prerequisites: Astro. 510, 511, 512.

BIOCHEMISTRY

John H. Pazur, *Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Clagett, Mallette, Pazur, Pritham, and Sullivan; Associate Professor Shigley; Assistant Professor R. Schraer. Associate Members—Associate Professor Phillips; Assistant Professors Loerch, McCarl, and Steinman.

Opportunities for research and graduate study are available in plant metabolism and photosynthesis, intermediary metabolism, nucleic acids, proteins, carbohydrates, lipides, enzymes, clinical chemistry, and endocrinology.

BIOCHEMISTRY

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are not required for admission. The Corn Products Lectures in Advanced Biochemistry enable the department to bring to the campus each year a group of distinguished visiting professors.

BIOCHEMISTRY (BIOCH)

401.	General Biochemistry (4)	*Mr. Clagett*
402.	General Biochemistry (4)	*Mr. Clagett*
404.	Food Chemistry (3-4)	
417.	Biochemical Methods (4)	*Mr. Loerch*
425.	Biophysical Chemistry (4)	*Mr. Mallette*
436.	Physiological Chemistry (3)	*Mr. Pritham*
437.	Physiological Chemistry (3)	*Mr. Pritham*
438.	Clinical Methods (3)	*Mr. Pritham*
439.	Independent Study (1-12)	

501. Enzymes (2) Investigations and theories concerning nature of enzymes, enzyme action, influence of chemical environment on enzyme action, and biological applications. Prerequisite: Bioch. 402 or 437. Fall term. *Mr. Clagett*

503. Biochemical Problems (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor. *Mr. Loerch*

507. Seminar in Biochemistry (1 per term)

510. Proteins, Amino Acids, and Peptides (2) Organic, physical, and biological chemistry of the naturally occurring compounds of this group. Prerequisites: Bioch. 425; 402 or 437. Fall term. *Messrs. Mallette and Steinman*

511. Carbohydrates (2) Chemical constitution and properties of carbohydrates; their metabolism in plant and animal organisms. Prerequisite: Bioch. 402 or 437. Spring term. *Mr. Pazur*

512. Lipides (2) Investigations on biochemistry of fats and related substances. Winter term. *Messrs. Shigley and McCarl*

516. Chemistry of the Pesticides (2) Lectures and assigned readings on the chemistry of insecticides, fungicides, herbicides, rodenticides, and related materials. Prerequisites: Chem. 31; Bioch. 402 or 437. Winter term, even years.

517. Endocrine Secretions (2) Chemistry of hormones and their physiological significance. Prerequisite: Bioch. 402 or 437. Spring term, even years. *Mr. Pritham*

519. Intermediary Metabolism (3) Processes involved in the utilization of metabolites in plants and animals. Prerequisite: Bioch. 402. Spring term. *Messrs. Mallette and Phillips*

520. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on proteins and enzymes. Prerequisite or concurrent: Bioch. 501, 510. Fall term. *Messrs. Clagett and Mallette*

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipides and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512. Winter term. *Mr. Shigley*

530. Special Topics in Biochemistry (2-4)

BIOLOGICAL SCIENCE

Edward D. Bellis, *Chairman of the Committee on Biological Science*
311 Life Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members—Professors Cooper, Grun, Hale, Kneebone, Schein, and J. E. Wright; Associate Professors Bellis and Kovar. Associate Members—Associate Professors Hillson and Wood.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including at least one year of chemistry. In addition, 18 credits in education and related psychology are required for admission to the M.Ed. program. As many as 6 credits may be made up as undergraduate deficiencies after the candidate is admitted to the Graduate School.

The candidate for the M.Ed. degree must earn at least 24 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in educational foundations and a term paper are required.

The D.Ed. program, designed for secondary school and college science teachers, requires a minimum of 60 credits in natural science, of which at least 45 must be in biological science. A minimum of 15 credits each is required in professional education and in thesis research. In addition, a reading knowledge of one foreign language is required.

BIOPHYSICS

Ernest C. Pollard, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Ginoza, Pollard, and H. Schraer; Associate Professors Deering, Person, Smyth, and Strother; Assistant Professors Snipes and Taylor. Associate Member—Assistant Professor Todd.

This program is designed for those interested in applying physical methods to the problems of living systems. A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. Opportunity to make up possible undergraduate deficiencies is provided in the program.

Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by the faculty. These include courses in physics, chemistry, biochemistry, zoology, botany, and microbiology.

BIOPHYSICS (BPHYS)

410. Special Topics (1-6)
473-474-475. Biophysics (2 each)

580. Biophysical Science (3) Theory of muscular contraction, heart action, and nerve conduction; X-ray analysis of proteins and nucleic acids; enzyme kinetics and thermodynamics.

581. Radiation Biophysics (2) The action of ultraviolet and ionizing radiation and of radioactive decay on biological systems: molecular and cellular aspects. Prerequisite: Bphys. 474.

582. Biophysics of Nucleic Acids (3) Biophysical studies on the structure and function of the nucleic acids, particularly those of bacterial and viral origin.

583. Special Topics in Biophysics (1-6 per term)

584. Seminar in Biophysics (1-3 per term)

585. Electron Microscopy in Biological Science (3) Principles of electron microscopy and application of techniques for the study of the ultrastructure of biological materials. Prerequisite: any of the following—Bphys. 473, Zool. 437, Bot. 405, Micrb. 401.

586. Biological Macromolecules (3) Biopolymer characteristics; polymer statistics; size and shape determination; methods of separation; polyelectrolytes; optical and mechanical properties; denaturation; degradation; biosynthesis. Prerequisite: Bphys. 475 or Chem. 451.

587. Ultracentrifugation (2) A laboratory course in ultracentrifugation techniques including applications to biophysical problems. Prerequisite: Bphys. 475.

590. Photobiology (2) Effects of visible and ultraviolet light on biological systems: energy absorption, transfer, utilization; photochemistry; metabolic and genetic responses; repair systems.

BOTANY

C. Leonard Fergus
In Charge of Graduate Programs in Botany
202 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Fergus, Grove, Grun, Kneebone, Kovar, O'Mara, Schein, Spackman, and Wright; Associate Professor Hamilton. Associate Members—Professors Hillson and Traverse; Assistant Professors Pursell, Therrien, Wagner, and Witham.

Programs are offered in plant anatomy, cytology, ecology, genetics, morphology, mycology, physiology, and taxonomy. A student having a degree in science or in one of the biological sciences is eligible for admission. Entering graduate students should have had basic courses in chemistry, mathematics, and physics.

See also "Plant Pathology" and "Genetics."

BOTANY (BOT)

400.	Comparative Plant Morphology (4)	*Mr. Hillson*
403.	Plant Biology for Teachers (3)	*Mr. Westerfeld*
404.	Plant Biology for Teachers (3)	*Mr. Westerfeld*
405.	(Zool. 405) General Cytology (3)	*Mr. Grun*
407.	Plant Anatomy (3)	*Mr. Hillson*
414.	Taxonomy of Vascular Plants (3)	*Mr. Keener*
419.	Mycology (3)	*Mr. Therrien*
420.	(Geol. 420) Paleobotany (3)	*Mr. Spackman*
421.	Botanical Technique (3)	*Mr. Pursell*
422.	(Zool. 422) Advanced Genetics (3)	*Messrs. Wright and Grun*
423.	(Geol. 423) Introductory Palynology (3)	*Mr. Traverse*
441.	Plant Physiology (3)	*Mr. Witham*
442.	Plant Physiology (3)	*Mr. Witham*
443.	Plant Physiology (3)	*Mr. Witham*
450.	Plant Autecology (3)	*Mr. Wagner*
451.	Plant Synecology (3)	*Mr. Kovar*

500. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Spring term. *Mr. Hamilton*

501. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years. *Mr. Fergus*

505. (Zool. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Bot. 405 or 422. Spring term, odd years. *Mr. Grun*

506. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Bot. 407. Spring term, even years. *Mr. Hillson*

511. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration, and catabolism. Prerequisite: Bot. 442. Fall term. *Mr. Hamilton*

512. Advanced Plant Physiology (3) Continuation of Bot. 511. Physiology of plants including photosynthesis, synthesis of cellular constituents, growth and development. Prerequisite: Bot. 442. Winter term. *Mr. Hamilton*

516. Ecological Plant Geography (3) Distribution of plant communities; environmental factors which influence their present distribution; geological-historical development of plant communities, their past distribution. Winter term, odd years. *Mr. Kovar*

518. Special Problems (1-12) Prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

521. Medical and Industrial Mycology (3) Structure, life histories, classification, and techniques of study of the fungi pathogenic to man and of fungi important in industry. Fall term, odd years. *Mr. Fergus*

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxonomy, phylogeny, and life histories; identification and field work. Prerequisite: Bot. 419. Winter term, even years. *Mr. Fergus*

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phylogeny, and life histories. Prerequisite: Bot. 419. Spring term, even years. *Mr. Fergus*

524. (Zool. 524) Seminar in Genetics (1 per term) *Messrs. Wright and Grun*

526. (Geol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Traverse*

533. (Zool. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origin, developmental tendencies, structure, and paleobotanical evidence. Winter term, odd years. *Mr. Grove*

536. Morphology of Angiosperms (3) Floral origin and development, fertilization, embryogeny, seed and fruit development. Prerequisite: Bot. 400. *Mr. Hillson*

537. (Sec.Ed. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term only.

538. Botany Seminar (1 per term) Presentation and discussion of selected topics.

539. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornworts, and mosses; collection, preservation, culturing, and cytologic techniques. Spring term, even years. *Mr. Pursell*

540. Algology (4) Comparative morphology, taxonomy, and ecology of fresh water and marine algae; culturing, collection, preservation techniques. Prerequisite: Bot. 421. Spring term, odd years. *Mr. Hillson*

BUSINESS ADMINISTRATION

Max D. Richards
In Charge of Graduate Programs in Business Administration
102 Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty: Senior Members—Professors Beranek, Bradley, Carzo, Cook, Coyle, Ferrara, Gotterer, Greenlaw, Kelley, McKinley, Pashek, Phillips, Richards, Rigby, Saylor, Schrader, Strong, Waters, and Wherry; Associate Professors Babione and Hammond. Associate Members—Professors G. K. Nelson, Phalan, and A. L. Williams; Associate Professors Beik, Bennett, Clewett, Cramer, Frey, Hottenstein, Millman, Shilling, and Yanouzas; Assistant Professors Copeland, Kelly, and R. D. Smith.

The M.B.A. program is designed for those desiring professional education in business administration, regardless of their educational background, in preparation for administrative positions primarily in business firms.

An applicant with little or no training in business administration may be admitted to the M.B.A. program and may be required to schedule up to 30 undergraduate credits of preparatory courses while pursuing the graduate program. Three credits are required as preparatory courses in accounting, business law or legal environment of business, business statistics, calculus, financial management, finite mathematics, macroeconomics, microeconomics, management, and marketing.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching.

For admission to the M.S. program approximately 30 acceptable undergraduate credits in business administration, economics, and mathematics may be required. An applicant may be admitted with deficiencies to be made up without degree credit.

Applicants to any of the graduate programs in business administration are required to take the Admission Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. The test is given at University Park and at numerous locations in most states and foreign countries in November, February, April, and July. For dates and locations, see the *Bulletin of Information*, Admission Test for Graduate Study in Business, Educational Testing Service, Princeton, New Jersey. Applicants should read the bulletin carefully. All arrangements for taking the test are made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. Advanced Accounting (3)
403. Auditing Concepts and Techniques (3)
404. Managerial Accounting (3)
406. Advanced Federal Tax Accounting (3)
409. Machine and Electronic Accounting Methods (3)

*398G. Accelerated Elementary Accounting (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to graduate students only.

500. Accounting Seminar (3-6)

503. Seminar in Auditing (3) The attest function of independent public accountants, verification of financial statements; problems of evidence, independence, ethics, professional responsibilities. Prerequisite: Acctg. 403.

504. Seminar in Managerial Accounting (3-6) Accounting and the managerial processes of planning, control, and decision-making.

507. Seminar in Financial Accounting (3) Theoretical basis of financial accounting.

508. Contemporary Issues in Accounting (3) Selected problems of current interest to the accounting profession.

511. Interpretation of Account Data (3)

515. Development of Accounting Thought (3) Development of accounting thought from ancient civilizations to the present.

520. Problems in Accounting (3-6) Planned individual projects involving library, laboratory, or field work.

BUSINESS ADMINISTRATION (B A)

462. Problems in Trade and Transportation (3)

*No graduate credit is given for this course.

503. Seminar in Public Utilities (3)

517. International Business Practices (3) Practices of exporters and importers dealing in commodities traded in world markets under competition, monopoly, or governmental control. Prerequisite: B.A. 162.

540. Business Administration Theory and Practice (3) An integrating course primarily for M.S. students using cases requiring analysis involving interrelated aspects of business administration and control.

552. Business Research Methods (3) Research methods applicable to business problems with emphasis on means of obtaining data and the logic underlying research design.

555. Business and Society (3) Evolution of the business organization and the changing framework of its operations, responsibilities, and social control.

574. Business Research (1-3) A project paper, comparable in quality and scope of work to a graduate thesis, on problems of a company. Prerequisite: 15 credits of 400 and 500 courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the functional areas of business in relation to over-all company objectives. Prerequisite: 15 credits of 400 and 500 courses in business administration.

BUSINESS LAW (B LAW)

*398G. Accelerated Business Law (3) Social control through law: courts; policies underlying individual rights; negotiable and non-negotiable contractual rights in society. Open to graduate students only.

BUSINESS LOGISTICS (B LOG)

410. Transportation and Public Policy (3)
412. Transportation Decision Techniques (3)
420. Urban Transportation (3)

504. Problems in Business Logistics (3-6) Planned individual projects involving library, laboratory, or field work.

538. Transportation and Physical Distribution (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

565. Seminar in Business Logistics (3-6)

BUSINESS STATISTICS (B S)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)
451. Analytical Methods in Business (3)
452. Analytical Methods in Business (3)
461. Probabilistic Models in Business (3)
490. Special Topics (3-6)

*No graduate credit is given for this course.

*398G. Accelerated Business Statistics (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

FINANCE (FIN)

406. Investment Valuation and Management (3)
408 Credit Institutions (3)

*398G. Accelerated Financial Management (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision-making.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. Estate Planning (3)

500. Insurance Theory and Practice (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

504. Problems in Insurance (3) Planned individual projects involving library, laboratory, or field work.

510. Risk Management (3) Analysis of managerial problems and responsibility for risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

MANAGEMENT (MGMT)

430. Administrative Management (3)
432. Simulation of Management Systems (3)
435. Cases in Public Relations (3)

510. Operations Management (3) Integration and application of decision-making to operational and policy problems within the business firm.

520. Organization Theory (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

*No graduate credit is given for this course.

522. Personnel Management (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

530. Seminar in Management (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

MARKETING (MKTG)

410. International Marketing (3)
423. Sales Management (3)
424. Marketing Research (3)
427. Advanced Retailing (3)

*398G. Accelerated Marketing Management (3) Analyses of customer and market behavior, marketing systems and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

504. Problems in Marketing (3-6) Planned individual projects involving library, laboratory, or field work.

523. Seminar in Marketing (3-6) Research in modern marketing trends.

534. Marketing Management (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

BUSINESS EDUCATION

F. Wayne House
In Charge of Graduate Programs in Business Education
243 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Member—Professor House.

This program provides advanced preparation for teachers of business subjects for secondary schools and colleges. The subject-matter areas encompass secretarial, accounting, retailing, clerical, and general business sequences. The program may be adapted for the preparation of supervisors of business education.

A minimum of 18 acceptable undergraduate credits in education and psychology plus a minimum of 30 credits in business and business education subjects are required for admission.

All candidates specializing in business education are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanities.

*No graduate credit is given for this course.

BUSINESS EDUCATION (BUS ED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

511. Internship in Business Education Supervision (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CERAMIC SCIENCE

Floyd A. Hummel
In Charge of Graduate Programs in Ceramic Science
201 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Buessem, Faust, Hummel, and Williamson; Associate Professors Rindone and Stubican. Associate Members—Assistant Professors Bradt and McKinstry.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree.

The background for admission is a bachelor's degree in ceramics or in one of the related physical sciences. A knowledge of differential and integral calculus is required together with adequate physics and chemistry.

In view of the wide field covered by ceramic science, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass technology. This makes it easily possible for students whose major subject for the bachelor's or master's degree has been either physics or chemistry to take appropriate graduate studies in ceramic science.

Special facilities exist for research in the areas of clay mineralogy, phase equilibria, mineral synthesis, mechanical properties, ferrite and ferroelectric studies, glass technology, and high temperature reaction kinetics.

CERAMIC SCIENCE (CER SC)

400. (Min. 400) Nonmetallic Crystal Chemistry (2) *Mr. Brindley*
402. Principles of Ceramic Engineering (3) *Mr. Williamson*
404. Ceramic Seminar (1) *Mr. Hummel*
405. Ceramic Research and Design (1)
406. Rheology and Fluid Properties of Ceramic Systems (2) *Mr. Williamson*
407. Ceramic Materials Laboratory (2) *Mr. Williamson*
408. Heat Treatment of Ceramic Materials (1) *Mr. Stubican*
409. Heat Treatment Laboratory (2) *Mr. Stubican*
410. Phase Relations in Ceramic Systems (3) *Mr. Hummel*
411. Principles of Ceramic Processes (2) *Mr. Buessem*
412. Surface Chemistry of Ceramic Materials (1)
414. Principles of Ceramic Technology (2-3) *Mr. Hummel*
415. Principles of Glass Technology (3-4) *Mr. Rindone*
420. Refractories (2-3) *Mr. Stubican*
425. Ceramic Research and Design (2)
430. Electroceramics (2-3) *Mr. Buessem*

500. Seminar in Ceramic Science (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science. *Mr. Hummel and Staff*

501. Colloidal Behavior of Clays and Muds (2-4) Surface chemistry of clays; rheology of ceramic powders, suspensions, and pastes. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Science (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Brindley*

506. Mechanical Properties of Ceramic Materials (2-3) Experimental stress-strain-time relations in elasticity, anelasticity, plasticity, and rupture; theory of strength and control. *Mr. Buessem*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials. *Mr. Buessem*

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. The Constitution of Glass (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Mr. Rindone*

512. Selected Properties of the Vitreous State (2-3 per term) Measurement and interpretation of such properties as: radiation effects; viscoelasticity; electrical, mechanical, optical, and thermal properties. *Mr. Rindone*

515. Special Problems in Ceramic Science (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Science (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Hsu*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in ceramic science studies are listed under Mineral Sciences.*

CHEMICAL ENGINEERING

Merrell R. Fenske, *Head of the Department*
131 Chemical Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Braun, Fenske, Jones, Klaus, McCormick, and Quiggle; Associate Professor Hersh. Associate Members—Associate Professor Engel; Assistant Professors Daubert, Evans, and Kabel; Mr. Barton.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, mass transfer, transport phenomena, unit operations, unit processes, nuclear chemical engineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. The facilities for instruction and research in chemical engineering and petroleum chemistry include those of the Petroleum Refining Laboratory.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit.

CHEMICAL ENGINEERING (CH E)

404. Chemical Engineering Economics (3) *Mr. Engel*
405. Thermodynamics for Chemical Engineers (3)
406. Chemical Engineering Problems (3) *Mr. Engel*
410. Chemical Engineering Principles (3) *Messrs. Daubert and Kabel*
411. Chemical Engineering Principles (3) *Messrs. Daubert and Kabel*
412. Chemical Engineering Principles (3) *Messrs. Daubert and Kabel*
415. Analysis and Mathematical Simulation in Chemical Engineering (3)
420. Cryogenic Engineering (3)
422. Petroleum Processes and Products (2) *Mr. Peiffer*
426. Introduction to Transport Phenomena (3) *Mr. Engel*
430. Nuclear Chemical Engineering (3) *Mr. Evans*
435. Chemical Reaction Kinetics (2) *Mr. Kabel*
440. Chemical Engineering Materials (3) *Mr. Engel*
445. Chemical Engineering Research (1-5)
450. Process Dynamics (3)
460. Chemical Engineering (4) *Mr. Evans*

500. Seminar in Chemical Engineering (1) Required of all graduate students.

505. Special Topics in Chemical Engineering (2-12) Intensive study in the various specialized fields of chemical engineering.

508. Principles of Industrial Organic Chemistry (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452, Ch.E. 30.

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Mass Transfer (3) Problem course on developments in diffusion, fluid dynamics, and phase equilibrium.

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

530. Heat Transfer in Nuclear Reactors (3) Fluid flow, heat transfer, and design problems in nuclear reactor systems.

535. Applied Reaction Kinetics (3) Basic principles of chemical kinetics, simultaneous heat and mass transfer, and prediction of rates; their application to reactor design.

CHEMISTRY

Thomas Wartik, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Deno, Dixon, Fritz, Haas, Hisatsune, Hutchison, Jackman, Jordan, Lampe, Miller, Noll, Oakwood, Shamma, Skell, Steele, Wartik, and Zook; Associate Professors Allcock, Ascah, Benkovic, Bernheim, Hamilton, Hayes, Olofson, Richey, Rosenblatt, and Schempf. Associate Members—Assistant Professors Baldwin, Gold, Lotz, Lowe, Matwiyoff, Morris, and Stanko.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent, and the computer, cryogenic, petroleum, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at a departmental colloquium.

Applicants for admission should have had at least one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry. Mathematics through integral calculus is required, and a reading knowledge of at least one foreign language, preferably German, is expected.

Prior to scheduling their first term program, new students will take examinations in the four areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. Chemical Literature (1)
401. Seminar (1)
405. Nuclear and Radiochemistry (3)
410. Inorganic Chemistry (4)
411. Advanced Inorganic Chemistry (2)
423. Advanced Analytical Chemistry (3)
424. Advanced Analytical Laboratory (2)
426. Chemical Instrumentation (3-5)
431. Advanced Organic Chemistry Laboratory (3)
435. Advanced Organic Chemistry Laboratory (3)
439. Advanced Organic Chemistry (3)
448. Colloid Chemistry (3)
*451-452. Physical Chemistry (3 each)
453. Advanced Physical Chemistry (3)
454. Advanced Physical Chemistry (3)
455. Physical Chemistry of High Polymers (3)
*457-458. Experimental Physical Chemistry (1 each)
489. Introduction to Chemical Research (1-10)
490. Organic Chemistry for Teachers (4)
492. Advanced General Chemistry for Teachers (3)
493. Selected Topics in Chemistry for Teachers (3-12)
494. Chemical Demonstrations for Teachers (3)

500. Seminar in Inorganic Chemistry (1 per term)

501. Seminar in Physical Chemistry (1 per term)

502. Seminar in Organic Chemistry (1 per term)

503. Seminar in Analytical Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Theoretical foundations and contemporary developments.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12)

534. Theoretical Organic Chemistry (3) Modern theories of structure; resonance; interpretation of physical properties; theory of rates; equilibrium properties.

535-536. Organic Chemistry (3 each) Adapted to the needs of those doing research work in organic chemistry.

538. Organic Chemistry (3) Survey of organic chemistry arranged primarily for graduate students majoring in fields other than organic chemistry.

544. Chemical Thermodynamics (3) Development of thermodynamic theory

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Statistical Thermodynamics (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 544, 565.

560. Topics in Physical Chemistry (2-6)

563. Chemical Kinetics (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 565, 544.

565. Atomic and Molecular Structure (3) Introduction to modern theoretiral chemistry, spectroscopy, and structure of atoms and molecules.

566. Quantum Chemistry (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisite: Chem. 565. Prerequisite or concurrent: Math. 555.

567. Quantum Chemistry (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.

581. Experimental Methods in Petroleum Chemistry (1-12)

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS

Joseph H. Britton, *Head of the Department*
S-105E Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Britton, Harms, Morgan, and Smith; Associate Professors Broderick and de Lissovoy. Associate Member—Associate Professor Gravatt.

Programs are concerned with growth, development, and aging and with interpersonal processes in the family and the community. The department includes faculty in both the psychological and social sciences who are particularly committed to these interdisciplinary fields. The perspective encompasses the human life span and the individual's roles in marriage, parenthood, and other social institutions in various cultural settings.

Students are expected to emphasize one area of professional orientation. They may prepare for positions in teaching and research in colleges, secondary and elementary schools, and in nursery schools; for work as human development specialists with children, parents, or other adults; and for service in community agencies.

The department operates preschool and infant laboratories as part of the teaching and research program. Each unit has observational facilities, and there are adjoining rooms for study of individual and group behavior of children and of adults. Additional resources, such as the Psychology Clinic, the Special Education Center for Children, the Speech and Hearing Clinic, and the Computation Center, are available in other parts of the University.

The entering student should have at least 6 credits in the biological and physical sciences, 12 in the social sciences (including a basic course in both sociology and psychology), and 6 in human development and family relationships. Students not

meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate studies.

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CD FR)

415. Child Development and Family Relationships for Secondary Schools (3)
418. Family Relationships (3)
429. Advanced Child Development (3)
430. Teaching in Nursery School (1-6)
441. Nursery School Organization (3)
445. (Psy. 445) Development Throughout Adulthood (3)
481. Educational Methods with Preschool Children (3)

500. Nonthesis Research (1-6)

508. Parental Education (3) Discussion and use of methods, experiences, and programs which can be used effectively to help parents in dealing with problems of parent-child relationships.

515. The Teaching of Child Development and Family Relationships (3) Methods of selection and presentation of subject matter basic to understanding the development of children.

529. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

530. Problems in Child Development and Family Relationships (1-6) Problems involving individual research in library, laboratory, or field projects.

536. (Psy. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

545. The Family in Its Community (3) Cultural influences on family relationships; how the family orients its members to community living and group participation.

546. Seminar in Family Relationships (1-6) Reading, reports, and discussion of recent research in relationship aspects of family living; particular attention to studies of roles, crises, and adjustments within the family setting.

548. Survey of Research on Sexual Behavior (3) Survey and evaluation of the contributions to the studies of sex by H. Ellis, Freud, Malinowski, Terman, Kinsey, and others. Prerequisites: 12 credits at the 400 and 500 level in child development and family relationships, psychology, sociology, or anthropology; 3 credits in statistics.

549. (Psy. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application.

CIVIL ENGINEERING

Benjamin A. Whisler, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

CIVIL ENGINEERING

Graduate Faculty: Senior Members—Professors Brielmaier, Gotolski, Kountz, Nesbitt, Perez, Shulits, and Whisler; Associate Professors Barnoff, Blue, Larson, and Reich. Associate Members—Associate Professor Weeden; Assistant Professors Davinroy and McDonnell.

The entering student should be a graduate in civil engineering from an accredited college of engineering. Students may specialize in structures, hydraulics, transportation engineering, surveying, and sanitary engineering, or combinations of these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.

See also "Sanitary Engineering."

CIVIL ENGINEERING (C E)

400. Seminar (1-3)
401. Civil Engineering Projects (2-12)
421. Highways and Streets (3)
422. Transportation Engineering (3)
423. Traffic Characteristics and Vehicle Safety (3)
424. Civil Engineering Materials (3)
427. Highway Geometric Design (3)
431. Civil Engineering Construction (3)
444. Engineering Soil Characteristics (3)
445. Soil Exploration and Analysis (3)
446. Advanced Soil Mechanics (3)
447. Advanced Structural Analysis (3)
448. Advanced Structural Design (3)
451. Advanced Hydrology (3)
452. Water Resources and Computations (4)
462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control (3)

500. Seminar in Civil Engineering (1-6) Reports on researches and special topics. Course may be continued in subsequent terms.

501. Civil Engineering Projects (3-10) Investigation or design projects in structures, transportation, hydraulics, or civil engineering materials.

520. Pavement Design (3) Fundamental principles; properties of pavement components; design tests; design of flexible pavements; design of rigid pavements; pavement evaluation and strengthening.

521. Analysis of Transportation Systems (3) Transportation systems, development, classification characteristics, and analytical techniques.

522. Transport Operations (3) System elements, control devices, engineering design, administration to operation of transportation systems.

523. Urban Transportation Planning (3) Coordinated metropolitan transportation; characteristics of existing transportation systems, capacity, performance, costs, and quality of service; parking, future concepts in transportation.

524. Advanced Problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

525. Airport Planning and Design (3) Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas.

526. Design of Transportation Facilities (3) Basic principles and engineering design of truck terminals, railroad yards and terminals, bus terminals, and parking facilities.

527. Theory of Traffic Flow (3) Phenomenon of vehicular traffic flow; flow density relationships; spacing; gap counting; delays; problems involving interrupted flow; multiflow routes.

540. Advanced Structural Analysis (2-4) Geometry of flexure; continuous beams, frames, arches; elastic foundations, elastic supports; beams curved in plan; grids; folded plates; domes. Prerequisite: C.E. 46.

541. Advanced Structural Analysis (2-4) Redundant, continuous, hybrid trusses; influence lines; secondary stresses; framed arches; suspension systems; selection of bridge type; space framing. Prerequisite: C.E. 46.

542. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

544. Advanced Structural Design (2-4) Concrete working stress, ultimate strength, limit design; test behavior of beams, slabs, columns; simple and continuous prestressed concrete members. Prerequisite: C.E. 42.

545. Advanced Structural Design (2-4) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 41.

550. Engineering Construction (2-4) Contruction methods applied to foundations, buildings, bridges, and other civil engineering construction work. Prerequisites: C.E. 41, 42.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fluids (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Advanced Problems in Sanitary Engineering (3-10) Investigations, analyses, and reports on current topics in sanitary engineering.

574. Analytical Evaluations in Sanitary Engineering (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Sewage Treatment Plant Design (1-6) Design of works for treatment of sewage or industrial wastes. Prerequisite: C.E. 71.

578. Industrial Hygiene (3) Principles of control of industrial toxics and the protection of the worker and the community.

CLOTHING AND TEXTILES

Ruth W. Ayres, *Head of the Department*
S-120A Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Ayres and Tesi; Associate Professor Densmore.

Work may be taken with major emphasis in the textile area, which stresses the background natural sciences, or in the clothing area, which stresses the background social sciences. Candidates are accepted who have a strong foundation and a good record in any of the following: home economics, chemistry, sociology, economics, psychology, or art.

CLOTHING AND TEXTILES (CL TX)

400. Special Problems in Clothing and Textiles (1-6)
402. Fundamental Principles of Tailoring Construction (3) *Mrs. Larson*
403. Creative Pattern-Making (3) *Mrs. Larson*
404. Draping (3) *Mrs. Larson*
406. Fashion Promotion (3) *Mr. Tesi*
407. The Textile and Clothing Industry (3) *Mr. Tesi*
408. Intermediate Textiles (3) *Miss Densmore*
410. Clothing for the Family (3) *Mrs. Adams*
411. Advanced Clothing Construction (3) *Mrs. Larson*

500. Nonthesis Research (1-6)

501. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

506. Clothing Behavior (3) Analysis and interpretation of clothing behavior through the application of theories selected from the behavioral sciences.

507. Problems in Relation to Clothing Consumption (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries. *Mr. Tesi*

508. Special Problems in Clothing and Textiles (1-6) Individual directed study, investigation, and practice in selected phases of textiles and clothing.

509. Seminar in Clothing and Textiles (1-6)

510. Research Methods and Evaluation in Clothing and Textiles (1-6) *Miss Densmore*

511. Current Developments in Clothing and Textiles (1-6) *Miss Ayres*

512. History of Clothing and Clothing Construction (3)

513. Advanced Textile Technology (6) *Miss Densmore*

COMPARATIVE LITERATURE

Philip A. Shelley
In Charge of Graduate Programs in Comparative Literature
204 Schwab Auditorium

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Bayard, Hyslop, Lewis, Pasquariello, Shelley, Townsend, and Weintraub; Associate Professors Oldsey, Wellwarth, and West. Associate Members—Professor Podlecki; Associate Professor Timpe.

Programs are arranged through a meaningful selection of courses offered by the several departments of languages and literatures, both ancient and modern, as well as of those specifically in the category of comparative literature. Subjects appropriate to such programs of study in international literary and cultural relations include the currency, reception, and influence of writers and works in countries other than those of their origin; the origin, transmission, and evolution of international literary movements; the characteristics and relations of universal literary types, themes, and motifs; literary intermediaries; literary criticism; folk literature and folklore.

In addition to the general requirements for the several degrees the following specific ones are in force:

Master of Arts: Three courses each in two national literatures and two in comparative literature; also a thesis in comparative literature. Language requirements: a thorough reading knowledge of one foreign language in case English is that of one of the literatures selected; otherwise a thorough reading knowledge of both languages of the two foreign literatures comprising the program of study.

Doctor of Philosophy: Beyond the work represented by the attainment of the master's degree in comparative literature or its equivalent, additional courses distributed approximately equal in number among three or four national literatures, including those presented for the master's degree. Additional work in courses specifically labeled comparative literature and a dissertation treating a subject in this field are required. Language requirements: a working knowledge of three foreign languages approved by the candidate's doctoral committee and aural competence in one modern language in addition to English.

COMPARATIVE LITERATURE (C LIT)

401. Western Literature (3)
402. Western Literature (3)
403. Western Literature (3)
408. Heroic-Age Epics and Sagas (3) *Mr. Bayard*
443. (Ger. 443) Literary Relations of Germany with England and America (3-9) *Mr. Shelley*

470. Old Masters of the Modern Novel (3)
480. Introduction to Folklore (3) *Mr. Bayard*
486. Tragedy (3) *Mr. Wellwarth*
487. Comedy (3) *Mr. Wellwarth*
488. (Engl. 488) Modern Continental Drama (3) *Messrs. Weintraub and Wellwarth*

500. Seminar in Comparative Literature (3-6)

501. Comparative Method in Literary Studies (3)

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to backgrounds, development, themes, and characteristics. *Mr. Bayard*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. West*

588. Twentieth Century Drama (3) Translation and comparative analysis of previously untranslated plays. Prerequisite: fluent reading knowledge of a foreign language. *Mr. Wellwarth*

COMPUTER SCIENCE

Preston C. Hammer, *Head of the Department*
426 McAllister Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Gotterer, Hammer, and Schoenfeld; Associate Professor Laird. Associate Members—Associate Professors Barnes, McCammon, and Singletary; Assistant Professors Deutsch and Squires.

The department offers courses and is prepared to direct research in a variety of subfields of computer science, including foundations of computer science, languages and programming systems, numerical analysis, nonnumeric procedures, and heuristic methods. The Computation Center has modern digital equipment and systems available for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent of Cmp.Sc. 401 and at least three of the five following: (1) Math. 441 or 481, (2) Cmp.Sc. 410, (3) Math. 453, (4) Math. 454, (5) Math. 428 or E.E. 471. The remainder of these five must be completed for the M.S. or Ph.D.

The M.S. candidate must satisfactorily complete (a) Cmp.Sc. 510 or 511 and (b) Cmp.Sc. 530 or 540, in addition to the other requirements of the Graduate School.

Admission as a candidate for the Ph.D. normally requires completion of course requirements for the M.S. and a background equivalent to an undergraduate major in mathematics.

The Ph.D. candidate must pass three written examinations: one in a field of specialization, one in a field of mathematics, and the third in a related field approved by the doctoral committee.

COMPUTER SCIENCE (CMP SC)

401. Principles of Programming with Physical Science Applications (3)
402. Principles of Programming with Socal and Biological Science Applications (3)

403. Principles of Programming with Business Applications (3)
404. Information Structures (3)
410. Introduction to Computer Systems (3)
411. Systems Organization and Programming (3)
420. The Structure of Programming Languages (3)
430. Combinatorics and Graph Theory (3)
453. (Math. 453) Numerical Computations (3)
454. (Math. 454) Matrix Computations (3)
460. Logic and Computability (3)
490. Special Topics in Computer Science (1-9)
491. Computer Projects (3)

500. Theory of Automata (3) Foundations of computer science with emphasis on computability; logic and structure of finite automata. Prerequisites: Cmp.Sc. 401, 402, or 403; 3 credits in logic at the 400 level.

501. Algebraic Theory of Automata (3) Prerequisite: Cmp.Sc. 500.

510. Structure of Artificial Languages (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, string manipulation, formula manipulation, relation to linguistics. Prerequisites: 3 credits in logic or logical design at the 400 level; Cmp.Sc. 401, 402, or 403.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multi-access systems, multiprogramming, multiprocessing. Prerequisite: Cmp.Sc. 410.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 401, 402, or 403.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 401, 402, or 403.

590. Seminar in Computer Science (1-3) Topics from current research.

591. Special Topics in Computer Science (2-6)

592. Special Topics in Foundations (2-6)

593. Special Topics in Languages and Systems (2-6)

594. Special Topics in Nonnumerical and Self-improving Systems (2-6)

COUNSELOR EDUCATION

George R. Hudson
In Charge of Graduate Programs in Counselor Education
110B Education and Psychology Center

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Hudson, Hylbert, and Wellington. Associate Members—Associate Professors Britton and Kelz.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors, and rehabilitation counselors. Doctoral

programs prepare candidates for positions of responsibility and leadership in these same areas. Doctoral candidates must have a minimum of one year's work experience in their field.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits in economics, education, psychology, sociology, and physiology or anatomy with some credits in at least three of these areas.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

EDUCATIONAL SERVICES (ED SER)

403. Guidance Principles and Practices (3)
404. Teaching and Group Guidance About Occupations (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
410. Rehabilitation of the Mentally Ill (3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisites: Ed.Ser. 506, Ed.Psy. 451.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals.

505. Occupational and Educational Information (3) Occupational information for guidance purposes; educational information related to vocational choice and preparation. Prerequisite: Ed.Ser. 403.

506. Student Analysis Procedures for Counselors (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing.

507. Supervised Experience in Student Counseling (3) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Ed.Ser. 403.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Ed.Ser. 403.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Ed.Ser. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Ed.Ser. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisite: Ed.Ser. 511.

513. Supervision of Guidance Workers (3) Practical experience in supervising and evaluating work of counselors. Prerequisite: Ed.Ser. 507.

DAIRY SCIENCE

DONALD V. JOSEPHSON, *Head of the Department*
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Almquist, Cone, Flipse, Josephson, Keeney, Kesler, Patton, and Watrous; Associate Professor McCarthy; Assistant Professor Amann. Associate Members—Associate Professor Cloninger; Assistant Professor Thoele.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipide metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, zoology, or agricultural economics.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

DAIRY SCIENCE (D SC)

405. DAIRY CATTLE MANAGEMENT (3) *Mr. Cloninger*
418. DAIRY SURVEY (1) *Mr. Josephson*
427. MILK SECRETION (3) *Mr. Kesler*
428. DAIRY PRODUCTION PROBLEMS (1-6)
431. PHYSIOLOGY OF REPRODUCTION IN FARM ANIMALS (3) *Messrs. Almquist and Amann*

501. BUTTER AND CHEESE (1-6) Manufacture and handling of butter and cheese. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Watrous*

502. CONDENSED MILK AND MILK POWDER (1-6) Condensing and drying of milk. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Keeney*

503. PUBLIC MILK PROBLEMS (1-6) Handling milk in modern plants. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Watrous*

504. ICE CREAM MANUFACTURE (1-6) Manufacture of ice cream, ices, and other frozen milk products. Prerequisites: Bioch. 404, Micrb. 8. *Mr. Keeney*

505. DAIRY PLANT ECONOMICS (1-6) Economic factors involved in creamery operation and mangement. Prerequisite: D.Sc. 7. *Mr. Watrous*

507. DAIRY CATTLE MANAGEMENT (1-6) *Mr. Kesler and Staff*

508. DAIRY SEMINAR (1-6) Preparation and presentation of a paper on an assigned subject.

509. TESTING DAIRY PRODUCTS (1-6) Constituents of dairy products. Prerequisites: Bioch. 404, Micrb. 8.

510. DAIRY CATTLE FEEDING (1-6) Application of fundamental research in animal nutrition to the feeding of dairy cattle. Prerequisite: D.Sc. 1. *Mr. Kesler*

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Zool. 422, 3 credits in statistics. *Mr. Thoele*

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Mr. Josephson and Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. Flipse*

522. Research Procedures in Dairy Technology (3) Research problems and methods in dairy technology with major emphasis on dairy chemistry. Prerequisite: Bioch. 404. *Mr. Patton*

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

EARTH SCIENCES

E. Willard Miller
Chairman of the Committee on Earth Sciences
101 Mineral Sciences Building

Degree Conferred: M.Ed.

This program is designed to meet the needs of science teachers in secondary schools. The fields of study are astronomy, geography, geology, meteorology, and mineralogy.

The program prepares candidates to teach at least one field of the earth sciences, familiarizes them with at least two additional earth science subjects, and at the same time enables them to increase their competence in the physical sciences, the biological sciences, and mathematics.

The student selects one of the earth sciences as an area of concentration, takes at least 12 credits in it, and is required to write a term paper in that area. An additional 12 credits must be taken in at least two other fields of earth sciences, or in two earth science fields plus two courses selected from the biological sciences, chemistry, mathematics, or physics. Furthermore, 6 credits in educational foundations are required as a minor.

The following courses offered by the various departments are appropriate for students majoring in earth and space science: Astro. 430; Geog. 490, 491; Geol. 400, 401, 402; Gphys. 400; Meteo. 400, 401, 402, 403, 404; Min. 402.

ECONOMICS

GRANT N. FARR, *Head of the Department*
326 Boucke Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Budd, Coppock, Farr, Kaufman, Levine, Mares, Mason, Newman, Prybyla, Reede, Roose, Rozen, Saylor, and Stout; Associate Professors Klein, Myers, and Robinson. Associate Members—Associate Professors Lee, Riew, Sauerlender, and Stromsdorfer; Assistant Professors Feller, Fox, and Herendeen.

Opportunities are available for concentration in the following fields: economic analysis, economic doctrines, economic development of developed areas, economic development of underdeveloped areas, economic fluctuations, income distribution, industrial organization, international economics, comparative economic systems, labor economics, money and banking, public finance, quantitative economics, statistics, and regional economics.

The department may waive the requirement of a thesis for M.A. candidates.

To enter graduate work in economics a student should have completed 6 credits in economic principles, 9 in the social sciences, and either 3 in statistics or 6 in mathematics. All applicants must take the Graduate Record Examination in advanced economics and general aptitude.

ECONOMICS (ECON)

400. HISTORY OF ECONOMIC THOUGHT I (3)
401. HISTORY OF ECONOMIC THOUGHT II (3)
404. CURRENT ECONOMIC ISSUES (3)
405. ADVANCED ECONOMIC ANALYSIS (3)
412. ECONOMICS OF COLLECTIVE BARGAINING (3)
413. COMPARATIVE LABOR MOVEMENTS (3)
415. SOCIAL INSURANCE (3)
418. ECONOMICS OF WAGES AND EMPLOYMENT (3)
419. CASE STUDIES IN LABOR-MANAGEMENT RELATIONS (3)
423. STATE AND LOCAL TAXATION (3)
429. ADVANCED PUBLIC FINANCE (3)
433. INTERNATIONAL MONETARY ECONOMICS (3)
442. MONOPOLY, COMPETITION, AND THEIR REGULATION (3)
450. THE BUSINESS CYCLE (3)
451. MONETARY THEORY AND POLICY (3)
452. THE MONEY MARKETS (3)
461. ECONOMIC GROWTH: UNDERDEVELOPED AREAS (3)
462. ECONOMIC GROWTH: THEORIES OF UNITED STATES DEVELOPMENT (3)
475. (L.M.R. 475) THEORIES OF THE LABOR MOVEMENT (3)
480. MATHEMATICAL ECONOMICS (3)
490. INTRODUCTION TO ECONOMETRICS (3)
491. ANALYSIS OF LINEAR ECONOMIC MODELS (3)
499. FOREIGN STUDY IN ECONOMICS (2-6)

500. ECONOMICS SEMINAR (3-6)

506. PROBLEMS IN ECONOMICS (3-6) Planned individual projects involving library, laboratory, or field work.

507. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

508. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity approach to monetary theory; current issues in theory and policy.

510. Econometrics (3-6) Statistical estimation in mathematically formulated economic relationships.

512. Wage Determination (3) Development of wage and employment theory; structure of labor markets; impact of unions on income distribution, price level, and employment.

513. Development of Economic Doctrines (3-6)

515. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

516. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

517. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision-making and control.

572. Soviet and Other Centrally Planned Economies (3) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

595. Seminar in Econometric Theory (3-6) Advanced study in the theories and problems relevant to the application of statistical methods to economics. Prerequisites: 6 credits of Econ. 510 and Math. 409.

EDUCATION OF EXCEPTIONAL CHILDREN

William R. Carriker, *Head of the Department of Special Education*
101 Education and Psychology Center

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Bliesmer, Carriker, French, Heilman, McDonald, and Siegenthaler; Associate Professors Frick, Regal, and Smith. Associate Members—Associate Professor Berlin; Assistant Professors Cardon, Cartwright, and Haspiel.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally maladjusted, neurologically impaired, or crippled. A multidisciplinary approach is emphasized.

Prerequisites for a master's program include: a valid teaching certificate and 10 credits (2 of which must be in a practicum) in the education of exceptional children.

Applicants for doctoral study shall show evidence of (1) having completed a master's degree with "A" quality grades on at least one third of the graduate courses and (2) attaining a minimum score of 500 on both portions of the Graduate Record Examination, or 50 on the Miller Analogies Test, or 35 on the Quantitative Educational Device.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. Introduction to Exceptional Children (3)
401. Educational Adjustments for Exceptional Children (3)
403. Curriculum Development for Exceptional Children (2-6)
405. Practicum in the Education of Exceptional Children (1-12)
410. The Mentally Retarded (3)
420. The Mentally Gifted (3)
440. (S.P.A. 440) Survey of Speech and Hearing Disorders (3)
444. (El.Ed. 444) Reading Disabilities (2-3)
445. (El.Ed. 445, Sec.Ed. 445) Techniques in Remedial Reading (2-6)
454. Diagnosis of Educational Disabilities (3)
470. The Emotionally Disturbed (3)
480. The Neurologically Impaired (3)

500. Seminar in Special Education (1-6) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. Administration and Supervision of Educational Programs for Exceptional Children (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Ser. 480 or teaching or administrative or supervisory experience.

502. Internship in Special Education (2-10) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.

509. Problems, Projects, and Area Studies in Special Education (1-6) May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.

510. Problems in the Education of the Mentally Retarded (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.

520. Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.

545. (S.P.A. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. (S.P.A. 546) Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

554. Psychological and Educational Evaluation of Exceptional Children (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, and WAIS. Prerequisite: Psy. 559.

570. Problems in the Education of the Emotionally Disturbed (2-4) Prerequisite: E.E.C. 470.

580. Problems in the Education of the Neurologically Impaired (2-4) Prerequisite: E.E.C. 480.

EDUCATIONAL ADMINISTRATION

Walter J. DeLacy
In Charge of Graduate Programs in Educational Administration
303 Education and Psychology Center

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Davison, DeLacy, McAulay, Remaley, and Willower; Associate Professor Bosch.

Professional preparation programs are offered at the master's and doctor's degree levels for elementary and secondary school personnel whose objectives are to become principals, supervisors, superintendents, state education department personnel, or professors of educational administration.

Requirements for admission to a graduate program in educational administration include 18 approved undergraduate credits in education and psychology. Applicants for admission to the master's degree program are required to have had one year of teaching experience, or to be currently engaged in teaching. Two years of teaching experience are required for admission to the doctoral program.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600 or 610 thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the termination of the graduate program. Failure to register for doctoral thesis credits in any term, unless approved by the candidate's committee, shall be considered automatic withdrawal.

Although candidates are required to specialize in a field of professional education, they are also encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

EDUCATIONAL SERVICES (ED SER)

450. Visual and Other Aids in Safety Education (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)

565. Principles of School Supervision (2-3) Organization of supervision: planning the supervisory program; developing standards of teaching and learning; improvement of learning through tests and teacher rating. Prerequisites: 18 credits in education and 3 years' teaching experience.

566. The Elementary School Principal as Supervisor (2-3)

567. The Secondary School Principal as Supervisor (2-3) Improvement of instruction; improvement of teachers in service; evaluation of teaching procedures; methods of supervision; selection and use of textbooks. Prerequisite: 3 years' teaching experience.

568. The Elementary School Principal as Administrator (2-3) Duties of the elementary school principal in organizing and administering his school.

569. The Secondary School Principal as Administrator (2-4) Problems of schedule making, teachers' meetings, curriculum making and revision, organization of extracurricular and guidance programs. Prerequisite: teaching experience.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money mangement. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

574. State and National Education Programs (2-3) Existing state and federal functions and relations to education; proposed programs. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes; torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience; Ed.Ser. 573.

580. Seminar in School Administration (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

581. Educational Survey Techniques (2-3) Methods for appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

596. Seminar in Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Education (1-6) Independent work in the study of topics in education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

599. Internship in Public School Research (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

EDUCATIONAL PSYCHOLOGY

William Rabinowitz, *Head of the Department*
311 Education and Psychology Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors DiVesta, French, Lathrop, Mitzel, Rabinowitz, VanOrmer, and Withall; Associate Professors Sparks and Thevaos; Assistant Professor Seibel; Mr. Greenhill. Associate Members—Associate Professors Snyder and Wodtke; Assistant Professor Impellitteri.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Special facilities include a research design laboratory, a laboratory for computer-assisted instruction, a self-instruction media laboratory, facilities for film production and editing, and a closed-circuit television studio in Chambers Building used for both research and instruction. Facilities in other departments available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Requirements for admission include a broad undergraduate background including some college mathematics, a minimum junior-senior scholastic average of B, and a satisfactory scholastic aptitude rating on either the Graduate Record Examination or the Miller Analogies Test. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one third of their graduate credits of "A" quality.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in two related areas (one being in this department). Typically, the doctoral program of study would include at least one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, instructional media, measurement, social or industrial psychology, clinical psychology, experimental psychology, and developmental psychology.

EDUCATIONAL PSYCHOLOGY (ED PSY)

400. Statistical Interpretation of Educational Research (2)
406. Applied Parametric and Nonparametric Statistics in Education (3)
407. Regression and Correlation Methods for Educational Data (2)
421. Learning Processes in Relation to Educational Practices (3)
450. (Psy. 450) Principles of Measurement (3)
451. Appraisal and Interpretation of Standardized Group Tests (2)
475. Introduction to Educational Research (2)
476. Experimentation in Educational Psychology (3)

501. Current Topics in Educational Psychology (2-6) Study of the current literature in educational psychology with emphasis on historical and theoretical aspects of important areas of investigation. Prerequisites: Ed.Psy. 406, 450, and 421.

506. Advanced Techniques for Analyzing Educational Experiments (2) Advanced techniques for research in education; analysis of covariance; repeated measures; randomized block designs; Latin square; and other experimental arrangements. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

520. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 421.

522. Concept Learning in the Schools (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. Problem Solving in the Schools (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. Theories of Learning and Instruction (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.

530. Theory and Research in Programmed Learning (3) Research and trends in programmed learning; preparation of short programmed sequences for experimental analysis. Prerequisites: Ed.Psy. 450 and 421, or Psy. 404.

532. Survey of Media Research (3) Systematic study of media research in edu-

cational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

558. Scaling Educational and Psychological Measures (2) Unidimensional and multidimensional scaling models with emphasis on psychometric methods and brief attention to psychophysical methods. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

599. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING

Arthur H. Waynick, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.; M.Eng. (not offered on the University Park Campus)

Graduate Faculty: Senior Members—Professors Ferraro, Holt, Lewis, Mentzer, Nisbet, Ross, Volz, and Waynick; Associate Professors Etzweiler, Hale, Lee, and Quinn; Assistant Professor Lachs. Associate Members—Associate Professors Adams and Marsh; Assistant Professors Laxpati, Seliga, and Steele.

Course offerings and research facilities are available in the following areas: antennas, communications systems (conventional and laser), computers (including digital, analog, and network analyzer), control systems, energy conversion and distribution, electron devices, information theory, ionosphere research (geomagnetism and aeronomy), microwave theory and techniques, networks, plasmas and MHD, power system analysis, servomechanisms, and wave propagation. A bachelor's degree in engineering or science is required with courses in electrical circuits, fields, and electronics.

ELECTRICAL ENGINEERING (E E)

421a,b,c,d. Electrical Engineering Problems (1-10)
425. Symmetrical Components (3)
426. Transistors (3)
428. Linear Control Systems (3)
429. Control System Design (3)
432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
437. Engineering Applications of Complex Variables (3)

438. Electromagnetic Theory and Radiating Systems (3)
439. Pulse Techniques (3)
441. Active Circuits (3)
450. Network Analysis (3)
459. Introduction to Statistical Theory of Communications (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Switching Systems (3)
472. Introduction to Digital Computer Systems (3)

514. Quantum Electronics (3) Quantization of electromagnetic fields; quantum statistics of attenuators and amplifiers; analysis of laser oscillators; Glauber P-representation; photon detection and coherence. Prerequisite: Phys. 561.

520. Seminar (1) Required of all graduate students in electrical engineering. Conferences, reading, and presentation of technical papers.

521. Advanced Electrical Engineering Problems (1-10)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

526. Semiconductor Electronics (3) Advanced semiconductor theory and applications to transistors and other semiconductor devices; modern semiconductor circuits. Prerequisite: E.E. 426.

527. Linear Control Systems (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems; system stability. Prerequisite: E.E. 428 or M.E. 455.

528. Nonlinear Control Systems (3) Design of nonlinear automatic control systems; numerical methods; phase-plane methods; describing functions; optimum switched systems; Liapunov and Popov stability. Prerequisite: E.E. 428 or M.E. 455.

529. Optimal Control (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.

530. Optimal Control (3) Minimum-time and minimum-fuel controls; generalizations of the maximum principle; computational methods in optimal control. Prerequisite: E.E. 529.

532. Ultra-High-Frequency Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisite: E.E. 432.

535. Engineering Analysis (3) Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering. Prerequisite: E.E. 437.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electromagnetic fields using the Maxwell-Lorentz equations as applied to vector fields, special solutions to scattering, diffraction, and radiation problems. Prerequisite: E.E. 438.

550. Network Synthesis (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisites: E.E. 437, 450.

560. Statistical Theory of Communications (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.

561. Information Theory (3) Mathematical measurement of information: information transfer in discrete systems; redundancy, efficiency, and channel capacity; encoding systems. Prerequisite: E.E. 459 or Math. 409.

569. Simulation of Biomedical Systems (3) Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470 or Cmp.Sc. 401 and Biol. 11.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 43 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

ELEMENTARY EDUCATION

A. Madison Brewer, *Head of the Department*
150 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Bixby, Bliesmer, Brewer, Corle, Heilman, McAulay, and Russell; Associate Professors Bosch, Riedesel, and Zafforoni. Associate Members—Professor Alessandro; Associate Professor Alfke.

The graduate programs provide advanced professional preparation for kindergarten teachers, elementary school teachers, and curriculum specialists. For admission 18 credits in elementary education and teaching experience are required.

ELEMENTARY EDUCATION (EL ED)

401. Training in Nature for Camp Counselors (3)
426. Problems of Elementary School Arithmetic (2-3)

433. Teaching Social Studies in the Elementary Grades (2-3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (2-3)
444. (E.E.C. 444) Reading Disabilities (2-3)
445. (E.E.C. 445, Sec.Ed. 445) Techniques in Remedial Reading (2-6)
449. Teaching Children's Literature (2-3)
453. Special Problems in the Teaching of Elementary School English (2-3)
461. Elementary Education (2-3)
467. Advanced Theory of Kindergarten (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

526. Applications of Research in the Teaching of Elementary School Mathematics (3) Research applications dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of elementary school mathematics. Prerequisites: El.Ed. 426 and elementary teaching experience; Ed.Psy. 400.

533. Problems and Issues in Elementary School Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: El.Ed. 433 and elementary school teaching experience.

546. (Sec.Ed. 546) Seminar on Reading Instruction (3-6) Research, procedures, and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: El.Ed. 443 or Sec.Ed. 443.

557. Reading Clinic Practice: Remedial Procedures (1-9) Practicum in special classes for reading disabilities; corrective and remedial procedures; specific procedures for correction of various types of reading disabilities. Prerequisite: El.Ed. 444.

559. Reading Clinic Research (1-15) Prerequisites: El.Ed. 443 or Sec.Ed. 443; El.Ed. 444.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principles

underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers: administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

594. Seminar in Elementary Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in elementary education.

598. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

ENGINEERING ACOUSTICS

Richard O. Rowlands
Chairman of the Committee on Engineering Acoustics
227 Ordnance Research Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Brown, Johnson, Kendig, Rowlands, and Snowdon; Associate Professor Baker. Associate Member—Associate Professor Farwell.

The aim of this program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by the several departments of science, engineering, and arts, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Ordnance Research Laboratory.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, or speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Course work should be so distributed that one area is covered in depth while a substantial number of courses are chosen from a combination of the other areas.

ENGINEERING ACOUSTICS (E ACS)

500. Special Problems in Acoustics (1-6) Provides training in selected areas of acoustics by means of supervised investigations or studies. Prerequisite: Phys. 443.

511. Underwater Sound Propagation (4) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (4) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Modern Acoustic Signal Processing (4) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

514. Electroacoustic Transducers (4) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.

ENGINEERING MECHANICS

Robert M. Haythornthwaite, *Head of the Department*
105 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members—Professors Davids, Hardenbergh, Haythornthwaite, Hu, Neubert, Vierck, and Wislicenus; Associate Professor Sharma. Associate Members—Associate Professors Jaunzemis and Kiusalaas; Assistant Professors Hayek and Zamrik.

Graduate study is available in the following areas: (1) mechanics of rigid bodies including dynamics, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics.

ENGINEERING MECHANICS (E MCH)

400.	Advanced Strength of Materials (3)	*Mr. Zamrik*
401.	Elements of Vibrations (3)	*Mr. Vierck*
402.	Applied and Experimental Stress Analysis (3)	
403.	Mechanics of the Solid State (4)	*Mr. Hu*
404.	Research in Engineering Mechanics (1-6)	
407.	Numerical Methods of Analysis (3)	*Mr. Sharma*
408.	Elasticity and Engineering Applications (3)	*Mr. Kiusalaas*
409.	Advanced Mechanics (3)	*Mr. Hardenbergh*
410.	Mechanics of Space Flight (3)	*Mr. Hardenbergh*
412.	Experimental Methods in Vibrations (3)	*Mr. Neubert*
413.	Plastic Analysis of Structures (3)	*Mr. Hu*
414.	Elements of Material Science (3)	*Mr. Inman*
421.	Continuum Mechanics (3)	*Mr. Jaunzemis*
422.	Continuum Mechanics (3)	*Mr. Jaunzemis*
446.	Mechanics of Viscoelastic Materials (3)	*Mr. Sharma*

500. Advanced Mechanics of Materials (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13.
Messrs. Kiusalaas and Sharma

506. Experimental Stress Analysis (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507.

507. Theory of Elasticity and Applications (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13.
Messrs. Hu and Kiusalaas

508. Theory of Elastic Stability and Applications (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions; thin-walled cylinders subjected to internal pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics.

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potentials; applications. Prerequisite: E.Mch. 540. *Mr. Hayek*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 44 or 431. *Messrs. Davids and Jaunzemis*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 44 or 431.
Messrs. Vierck and Neubert

523. Relaxation Methods (3) Relaxation methods compared to iteration and other numerical methods of analysis; application to elasticity, plasticity, stability, fluid flow, heat transfer, and related fields. Prerequisites: E.Mch. 13 or 111, Math. 44. *Messrs. Vierck and Sharma*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: A.M. 451 or E.E. 435 or M.E. 452. *Messrs. Davids and Hayek*

Unit A (3) Basic concepts of tensors; matrices; numerical procedures; approximation; Fourier, Legendre, and other orthogonal series; applications; Bessel and other special functions.

Unit B (3) Basic solutions of Laplace, diffusion, wave equations; boundary-value problems; Fourier, Laplace transforms; contour integration techniques; Caignard's energy methods.

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained

oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical applications. Prerequisite: E.Mch. 522. *Mr. Neubert*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14.
Messrs. Hu and Zamrik

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507.

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. *Mr. Jaunzemis*

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540 or 421. *Mr. Jaunzemis*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

ENGINEERING SCIENCE

Samuel S. Lestz
Chairman of the Engineering Graduate Committee for Off-Campus Programs
302 Mechanical Engineering Building

Degree Conferred: M.Eng.

Programs leading to the degree of Master of Engineering with a major in engineering science are offered only at the King of Prussia Graduate Center and the Capitol Campus Graduate Center near Harrisburg. Details of the programs available may be obtained by writing directly to the dean in charge. Addresses are given on the inside front cover.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area.

Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits of course work is required, of which at least 12 must be at the 500 level. A scholarly written report is also required.

A bachelor's degree in engineering or a closely allied field is required for admission.

ENGLISH

HENRY W. SAMS, *Head of the Department*
245 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members—Professors Bayard, Condee, Cramer, Davis, Euwema, Frank, Goldberg, Lewis, Meserole, Rubin, Sams, Sutherland, Weintraub, and Young; Associate Professors Bressler, Jewkes, Oldsey, Wellwarth, and West. Associate Members—Associate Professors Austin, Borklund, Gidez, Hansen, Reed, and Trachtenberg.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work.

A thesis is required of all M.A. candidates in this major.

ENGLISH (ENGL)

406. HISTORY OF THE ENGLISH LANGUAGE (3) *Messrs. Bell, Buckalew, and Shedd*
407. HISTORY OF THE ENGLISH LANGUAGE FOR TEACHERS (3) *Messrs. Bell, Buckalew, and Shedd*
408. ADVANCED COLLEGE GRAMMAR (3) *Miss McElwee*
411. PROBLEMS OF STYLE (3)
412. THE WRITING OF FICTION (3-6) *Messrs. Rubinstein, Rogers, and West*
413. VERSE WRITING (3-6) *Mr. Haag*
414. BIOGRAPHICAL WRITING (3) *Mr. Weintraub*
418. ADVANCED TECHNICAL WRITING AND EDITING (3-6) *Mr. Houp*
422. MASTERS OF BRITISH LITERATURE (3-6)
423. HISTORY OF BRITISH LITERATURE (3)
424. MOVEMENTS IN BRITISH LITERATURE (3)
432. MASTERS OF AMERICAN LITERATURE (3-6) *Messrs. Bressler, Davis, and Staff*
433. HISTORY OF AMERICAN LITERATURE (3) *Messrs. Sutherland and Gidez*
434. MOVEMENTS IN AMERICAN LITERATURE (3-6) *Messrs. Hansen, Meserole, and Staff*
435. THE AMERICAN SHORT STORY (3) *Mr. Bressler*
437. AMERICAN POETRY (3) *Messrs. Rubin and Hansen*
438. AMERICAN DRAMA (3) *Mr. Wellwarth*
441. POETRY AND PROSE OF THE EARLY 17TH CENTURY (3) *Mr. Condee*
442. POETRY AND PROSE OF THE LATE 17TH CENTURY (3)
443. JACOBEAN AND CAROLINE DRAMA (3) *Messrs. Jewkes and Reed*

444. Shakespeare (3) *Messrs. Arnold, Jewkes, and Reed*
445. Chaucer (3) *Mr. Frank*
446. Milton (3) *Mr. Condee*
447. Poetry and Prose of the 16th Century (3) *Mr. Reed*
448. English Drama Before Shakespeare (3) *Mr. Jewkes*
449. Shakespeare (3) *Messrs. Arnold, Jewkes, and Reed*
451. Poetry and Prose of the Early 18th Century (3) *Mr. Sams*
452. Poetry and Prose of the Late 18th Century (3)
455. The Novel in England to Jane Austen (3)
458. The Drama from Dryden to Sheridan (3) *Mr. Rogers*
461. British Non-Fictional Prose of the 19th Century (3) *Mr. Cramer and Miss Austin*
462. Wordsworth and Coleridge (3) *Mr. Cramer and Miss Austin*
463. Byron, Shelley, and Keats (3)
465. Victorian Novel (3) *Miss Austin*
466. The American Novel to 1900 (3) *Messrs. Young and Oldsey*
467. Victorian Poetry (3) *Mr. Cramer*
470. Literature of the British Commonwealth (3) *Mr. Sutherland*
475. Modern British Fiction (3) *Messrs. Sutherland and Weintraub*
476. The American Novel Since 1900 (3) *Messrs. Young and Oldsey*
477. British and American Poetry of the 20th Century (3)
478. British and Irish Drama Since 1890 (3) *Mr. Weintraub*
481. History of English Literary Criticism (3) *Messrs. Sams, Bressler, and Borklund*
488. (C.Lit. 488) Modern Continental Drama (3) *Messrs. Weintraub and Wellwarth*
490. Rhetorical Theory and Practice (3) *Mr. Bowman*
491. Literature for Teachers in Secondary Schools (3) *Mr. Bressler*
*498. English Institute (6-12)

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Messrs. Meserole and Mann*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry. *Mr. Jewkes*

522. Old English Literature (3) A reading of the more important poetic works in Old English. *Mr. Jewkes*

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Mr. Cramer*

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Mr. Cramer*

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Cramer*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the 19th and 20th centuries. *Mr. Davis*

*A maximum of 6 credits in one summer.

540. Studies in Elizabethan Prose and Poetry (3-6) *Mr. Reed*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Mr. Frank*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer. *Mr. Frank*

543. Studies in Early 17th Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700.

545. Chaucer (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Mr. Frank*

546. Milton (3) The poetry and prose of John Milton. *Mr. Condee*

548. Elizabethan and Jacobean Drama (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

549. Shakespeare (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Mr. Reed*

552. Swift and Pope (3) *Mr. Sams*

553. The Age of Johnson (3) The work of Johnson and his circle.

554. Studies in Early American Literature (3) *Messrs. Meserole and Hansen*

555. The Puritans (3) Critical studies of the principal works of English and American Puritans. *Messrs. Meserole and Hansen*

556. Eighteenth Century British Fiction (3)

557. Early 18th Century British Literature (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. American Romanticism (3) The Romantic movement in American literature of the mid-19th century. *Messrs. Rubin, Davis, and Bressler*

561. Studies in the Romantic Movement (3-6) *Mr. Cramer*

562. Studies in the Literature of Victorian England (3-6) *Mr. Cramer and Miss Austin*

564. Studies in 19th Century American Literature (3) The major figures treated will vary from year to year. *Messrs. Rubin, Davis, and Oldsey*

573. Studies in 20th Century British Literature (3-6) Major writers and literary movements. *Mr. Weintraub*

574. Studies in 20th Century American Literature (3-6) Major writers and literary movements. *Messrs. Young and Lewis*

575. James Joyce (3-6) Alternate terms: *Ulysses* and *Finnegans Wake*. Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed.

576. Hemingway and Faulkner (3) The major works. *Mr. Young*

578. Shaw (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. Eliot (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Mr. Lewis*

581. Contemporary Literary Criticism (3) *Mr. Sams*

582. Hawthorne and Melville (3) Detailed study of the major works of both authors and of the relationship between the two men. *Mr. Young*

583. Emerson and Thoreau (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Bressler*

584. Whitman and Dickinson (3) The major texts, with special emphasis on background and language. *Messrs. Rubin and Davis*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature. *Mr. Lewis*

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserole*

590. Research Problems in British Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

591. Research Problems in American Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early 16th century to the present. *Mr. Bayard*

595. Studies in British Fiction (3-6) *Messrs. Sutherland and Weintraub*

596. Studies in American Fiction (3-6) *Messrs. Lewis and Young*

597. Studies in American Poetry (3-6) *Messrs. Rubin, Davis, and Hansen*

598. Readings in English (1-6) Programs of readings in English and American literature, designed to meet specific needs of individual students.

ENTOMOLOGY

Beckford F. Coon, *Head of the Department*
101 Walker Laboratory

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members—Professors Asquith, Coon, Frear, and Rutschky; Associate Professors Smyth and Snetsinger; Assistant Professor Mumma. Associate Members—Associate Professors Boyle, Ercegovich, and Yendol; Assistant Professors Benton and Kearby.

A student majoring in entomology may specialize in various areas of economic entomology and in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect transmission of

plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Rutschky*
402. Insect Ecology (3) *Mr. Kearby*
403. (Zool. 403) Systematics (3) *Mr. Boyle*
405. Insect Morphology (3) *Mr. Rutschky*
411. Insect Physiology (3) *Mr. Smyth*
413. Entomology Seminar (1 per term)
429. Insect Control (3) *Mr. Hower*
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

506. Immature Insects (3) The morphology and taxonomy of the immature stages of insects. Spring term, even years. *Mr. Rutschky*

520. Special Topics (1-6)

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years.

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications.

533. Physiology of Nerves, Muscles, and Sense Organs (2-6) Current literature on the function of excitable tissues of insects and other animals. Prerequisite: a 400-level course in physiology, biophysics, or physiological psychology. *Mr. Smyth*

535. Biological Control (3) Practical and theoretical aspects of the biological control of arthropod pests. Spring term, even years. *Mr. Yendol*

540. Insect Resistance in Plants (2) Mechanism, expression, permanence, and measurement of resistance to insects with special reference to farm crops. Spring term, odd years. *Mr. Coon*

EXTENSION EDUCATION

Emory J. Brown
Chairman of the Committee on Extension Education
204 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competencies which enable them to become more effective professional workers. Options have been developed for the Colleges of Agriculture and Human Development. Additional options will be offered as they are developed by other Colleges.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

FAMILY ECONOMICS AND HOME MANAGEMENT

Marjorie M. Knoll
Head of the Department of Home Management, Housing, and Home Art
S-250 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professor Knoll; Associate Professor Nichols. Associate Members—Professor Hotchkiss; Associate Professors Gage and Van Dommelen; Assistant Professor Smith.

Those interested in emphasizing a study of home management, family economics, family housing, and home equipment may do so through this major. There are no specific course requirements for admission.

The following courses are available in the area of family housing; their descriptions may be found under the offerings of Home Art: F.H.H.Ar. 401, 440, 441, 470, 515, 530, 541.

In the graduate program family management practices, their effects upon members of the family unit, and the interaction of such practices with the local and national economy are studied in relation to principles of economics, philosophy, psychology, sociology, and political science.

CONSUMER SERVICE AND EQUIPMENT (CS EQ)

403. Lecture-Demonstration Techniques (3)
413. Home Equipment (3)
450. Problems in Household Equipment (1-6)

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

415. Household Buying Practices (3)
419. Managing Family Financial Resources (3)
424. Economic Conditions in Relation to the Family (3)
439. Management Principles in Home Operation (2)
442. Resident Experience in Home Management (3) Room and board will be charged at regular rates.
445. Home Management Experience (3)
477. Family Management (3)

515. Consumer Problems (2-3) Methods of securing, evaluating, and presenting data concerning household commodities. For home economics teachers in high schools, colleges, and adult classes.

524. Economic Problems of the Household (3) Economic problems of the present-day family; special emphasis on factors in household production, use of money income, and standards of living.

528. Home Management Supervision (2-3) Evaluation of objectives and techniques in organization, supervision, and teaching of the home management house experience.

543. Home Management in Relation to Family Living (3) Includes work with families in solution of their management problems.

544. Problems in Family Economics and Home Management (1-6) Investigation of selected problems in family economics and home management.

550. Seminar in Family Economics and Home Management (1-6) Discussion and reports on developments in family economics and home management.

FOOD SERVICE AND HOUSING ADMINISTRATION

S. Earl Thompson
Head of the Department of Hotel and Institution Administration
4A Human Development Building

Degrees Conferred: M.S., M.Ed.

Graduate work in this field trains for management positions in institutions which provide food service and housing to large groups, such as hospitals, residence halls, children's homes, and other public and private organizations. For admission, a student should have a baccalaureate degree in this or a related field.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (2)
410. Advanced Quantity Food Production (3)
425. Food and Labor Management and Control (3)
461. Personnel Functions in Food Service and Housing Administration (3)
470. Problems in Food Service and Housing Administration (3)

502. Problems in Institution Administration (3-6) Individual study of problems in institution administration. Prerequisites: F.S.H.A. 310, 330.

FOODS AND NUTRITION

George P. Barron, Jr., *Head of the Department*
202B Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., and M.Ed. in Foods and Nutrition; M.S. in Nutrition in Public Health.

Graduate Faculty: Senior Members—Professors Barron and Pike; Assistant Professor Cox.

Graduate programs in foods and nutrition prepare students for careers in college teaching, research, and adult program leadership. The program in nutrition in public health prepares the student for work in public health agencies.

For admission to a graduate program in foods and nutrition, a student must have completed at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 3 in physiology, 4 in other physical and biological sciences, and 8 in foods and nutrition.

For admission to the program in nutrition in public health, the requirements are at least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in microbiology, 12 in social sciences, 7 in foods, and 4 in nutrition.

FOODS AND NUTRITION (F N)

400. Special Problems in Foods and Nutrition (1-3)
420. Experimental Cookery (3)
421. Cultural and Aesthetic Aspects of Food (3)
422. Scientific Principles of Food Preparation (3)
452. Nutritional Aspects of Disease (3) *Miss Pike*
456. Nutrition in the Community (3)
457. Principles of Nutrition (3) *Mr. Cox*
458. Applied Nutrition (2) *Mrs. Guthrie*
459. Advanced Nutrition (3) *Mr. Cox*
490. Foods and Nutrition Seminar (1)

520. Readings in Foods (2) Critical review and reports of literature on selected food topics.

521. Seminar in Foods (1-6) Discussion and reports on current research in the foods field.

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

552. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy. *Miss Pike*

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged. *Mr. Barron*

556. The Survey Method in Foods and Nutrition (2) Study of survey technique as a tool in the assay of food adequacy and nutritional status. *Mr. Barron*

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition. *Miss Pike*

FORESTRY

Wilber W. Ward
Director of the School of Forest Resources
101 Forestry Building

Degrees Conferred: Ph.D., M.S., M.F.

Graduate Faculty: Senior Members—Professors Fletcher, McDermott, Norton, and Ward; Associate Professors George, Gerhold, Shipman, and Sopper. Associate Members—Professor Bartoo; Associate Professors Hutnik, Lindzey, and Murphey; Assistant Professors Borden and Elers.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in timber management, wildlife habitat management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar program emphasizing biological science, economics, and applied mathematics provides the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engineering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

FORESTRY (FOR)

403. Dendrology (3)
410. Forest Resources Seminar (1)
416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
440. Forest Economics and Finance (3)
450. Advanced Mensuration (3)
455. Forest Photo Interpretation (3)
466. Forest Resource Management (3)
469. (W.S. 469) Problems in Forestry and Wood Science (1-6 per term)
480. Policy and Administration (3)

504. (W.S. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 308.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Bot. 516.

510. Forestry Seminar (1 per term) Current problems of forest research presented as weekly seminar reports. May be repeated with additional credit for each term's work.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerequisite: Bot. 22.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.

WOOD SCIENCE (W S)

411. Physical Properties of Wood (3)
412. Mechanical Properties of Wood (3)
413. Chemical Properties of Wood (3)
420. Processing and Machining of Wood (2)
421. Adhesives and Finishes for Wood Products (2)
422. Seasoning and Preservation (2)
424. Commercial Tropical Woods (3)
430. Forest Products Manufacturing Systems and Standards (3)
437. Wood Micro-Technique (3)
462. Defects in Wood (3)
469. (For. 469) Problems in Forestry and Wood Science (1-6 per term)
491. Logging and Lumbering (3)
495. Forest Products Production Management (3)
497. Small Sawmills (3)

502. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose; pulping quality, fiber measurements.

504. (For. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

510. Wood Utilization Seminar (1 per term)

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

540. Chemical Utilization of Wood (3) Wood as a chemical raw material; its chemical properties and conversion processes.

FRENCH

Gérard J. Brault, *Head of the Department*
210 Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Belasco, Brault, Chapman, Eyer, Hyslop, and LeSage. Associate Member—Assistant Professor Knight.

The minimum requirement for admission to an advanced degree program will normally be 27 credits of post-intermediate work in language and literature. A student may follow a graduate program in French literature and in descriptive and historical linguistics with a minor in a related field. M.A. candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

FRENCH (FR)

417. French Phonology (3)
418. French Morphology and Syntax (3)
422. Old French Literature (3)
426. French Literature of the Renaissance (3)
435-436. 17th Century French Literature (3 each)
445. The Age of Enlightenment (3)
451-452. 19th Century French Literature (3 each)
460. French Prose of the 20th Century (3)
461. French Poetry and Drama of the 20th Century (3)
470. Advanced Composition and Conversation (3)
480. The Teaching of French (4)
*489. French Institute (7-14)
491. Problems in French Literature (3-6)
499. Foreign Study in French (3)

†1G. Elementary French for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

500. An Introduction to Old French (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments.

503. French Phonology (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar.

504. French Morphology and Syntax (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics.

505. Semantic Theory of the French Language (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints.

* A maximum of 7 credits in one summer.
† No graduate credit is given for this course.

516. The Song of Roland (3) Seminar in the Old French *Chanson de Roland,* with emphasis on the problems of textual criticism and literary analysis.

517. Villon (3) The poetry of Villon with reference to the cultural and social context of the late medieval period.

518. Medieval French Drama (3) The development of French drama from its liturgical origins to the flourishing comic theater of the late Middle Ages.

526. Rabelais (3) Seminar in works of François Rabelais, notably Book I (Pantagruel) and Book II (Gargantua), with emphasis on comic devices and narrative technique.

527. French Renaissance Poetry (3-6) Evaluation of French poetry from Marot through the Pléiade; emphasis on Ronsard and DuBellay.

528. Montaigne (3) Genesis and evolution of Montaigne's creation of the personal essay; influence of the *Essais* in 17th, 18th century French literature.

533. Seventeenth Century Prose and Poetry (3) The development of Classicism; its apogee and decline as seen in the works of major prose writers and poets.

534. Moliere (3) The literary achievement of Moliere, the comic playwright, director, actor, and founder of the Comédie française.

535. Seventeenth Century French Tragedy (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine.

536. La Fontaine (3) The literary artistry of La Fontaine with special emphasis on his contribution as a fabulist.

540. Voltaire (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry.

541. Rousseau (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau precursor of Romanticism.

542. Diderot and the Encyclopedists (3) The literary *philosophe* in the Age of Enlightenment with special emphasis on Diderot and his collaborators on the *Encyclopédie.*

561. French Romanticism (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry.

565. The Ninteenth Century French Novel (3) The development of the novel in the 19th century with emphasis on Constant, Balzac, Stendhal, Flaubert, and Zola.

568. Baudelaire (3) A study of his poetry and his criticism.

569. Masters of 20th Century French Literature (3-6) Major literary figures of contemporary French literature.

581. Theory and Techniques of Teaching French (1-3)

596. Symbolism (3) The anti-positivistic tradition in 19th century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

597. Research Techniques and Bibliography in French Language and Literature (1-3)

598. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

FUEL SCIENCE

Peter H. Given
In Charge of Graduate Programs in Fuel Science
316 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Given, Palmer, and Walker; Associate Professor Austin; Assistant Professor Polansky. Associate Members—Associate Professor Vastola; Assistant Professor Becker.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree.

Research facilities, well instrumented, are available for the study of high temperature gas reactions by shock-tube and other techniques, electrochemical kinetics of fuel cell and battery systems, reactions in plasmas and flames, physics and chemistry of carbons and graphites, fundamental processes in the combustion of liquid and solid fuels, mass spectrometric investigation of the structure of solids, comminution of brittle materials, and the organic geochemistry of plant-derived sediments. Students can plan a wide variety of programs of study, to suit individual needs; coherent interdisciplinary programs are encouraged.

Students may be accepted with a B.S. or M.S. degree in chemistry, physics, chemical, aeronautical or mechanical engineering or fuel science.

A basic minimum of 30 course credits is required for the Ph.D. degree, of which at least 12 must be in departmental courses.

FUEL SCIENCE (F SC)

400. Fuel Science Research and Design (1-10 per term)
410. Fuel Science Laboratory (1) *Mr. Polansky and Staff*
411. Mathematical Modeling for Fuel Scientists (3)
421. Flames (3)
422. Combustion Engineering (3)
423. Combustion Laboratory and Field Trips (1)
424. Energy in Space Travel (3)
425. Selected Topics in Fuel Science (3)

504. (Gchem. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

506. Kinetics of Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of coals and carbons. Prerequisite: Chem. 451. *Mr. Walker*

510. Special Topics in Fuel Science (1-6 per term)

511. Fuel Science Seminar (1 per term) Selected topics from current research relevant to fuel science.

512. High Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.Sc. 421. *Mr. Palmer*

515. Catalysis of Fuel Reactions (2) Principles of chemisorption and catalysis; mechanisms of specific catalytic reactions and practical aspects of catalytic processes in the fuels industries. Prerequisite: Chem. 452. *Mr. Walker*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in fuel science studies are listed under Mineral Sciences.*

GENERAL ENGINEERING

Otis E. Lancaster
Chairman of the Committee on General Engineering
101 Hammond Building

Degrees Conferred: M.Ed., M.Eng.

This program is designed primarily to meet the needs of the engineering faculty in the various technical institutes. The objective is to give academic preparation to those individuals who will teach engineering subjects at the two-year college level.

For admission an undergraduate degree in engineering, physical science, mathematics, or the equivalent is required.

For either degree a minimum of 30 credits is required in addition to a scholarly written report. Twenty-four of these credits should be in engineering, physics, and mathematics. A candidate is expected to earn at least 3 credits each in mathematics, physics, and two fields of engineering, or demonstrate competence in them.

For the M.Ed. 6 credits must be in education, consisting of one 3-credit course in the theory of learning and teaching and one 3-credit course in internship in college teaching. Fifteen credits must be earned at the 500 level.

For the M.Eng. degree 6 credits may be taken in any field approved by the committee, but at least 12 credits in engineering subjects must be at the 500 level.

GENERAL FAMILY STUDIES

Rose M. Cologne
In Charge of Graduate Programs in General Family Studies
20A Human Development Building

Degrees Conferred: M.S., M.Ed.

Because this program is planned for teachers in secondary schools or small colleges and others who wish to become proficient in several areas of home economics, the

student must have a strong home economics background for admission.

The major for the M.S. or M.Ed. degree consists of a minimum of 6 credits in each of three areas of home economics. The student chooses a minor field of educational foundations or, if sufficient competence in educational foundations is demonstrated, one of the applied fields, such as home economics education, secondary education, or higher education.

GENERAL FAMILY STUDIES (G F S)

410. Communities and Families (3)

516, 516v. Methods of Research in Home Economics (3) Review of problems and techniques of research in home economics. Required of all graduate students in home economics.

GENETICS

James E. Wright, *Chairman of the Committee on Genetics*
307 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Buss, Grun, W. I. Thomas, D. E. Walker, J. E. Wright, and Zimmerman; Associate Professors Cleveland, Creech, Gerhold, Hicks, Person, and Starling. Associate Members—Associate Professors M. W. Johnson and Pfeiffer; Assistant Professor Craig.

Graduate programs are offered in the fields of theoretical and applied genetics, including plant and animal breeding. Courses in genetics and breeding are given by various departments. The basic and theoretical courses are listed under identical numbers. Courses dealing with genetic principles as applied to specific organisms are offered in the Departments of Agronomy, Animal Science, Dairy Science, Forest Management, Horticulture, Microbiology, and Poultry Science. The graduate committee for majors shall be appropriately represented by members of theoretical and applied phases who shall have the responsibility and jurisdiction for determining course work and research acceptable in satisfying degree requirements.

For entry as a major in this field no fewer than 15 credits in basic biology and 15 credits in the areas of chemistry, mathematics, and physics are required.

The following courses are available in genetics or breeding, and their descriptions may be found under the offerings of the several departments: Agro. 411, 509, 510, 582; A.I. 501, 505; An.Sc. 422; Bot. (Zool.) 405, 422, 505, 524, 533; D.Sc. 513; For. 512; Hort. 407, 444, 501, 514, 520, 524; Micrb. 516; Pty.Sc. 402, 505.

GEOCHEMISTRY

Arnulf Muan
Head of the Department of Geochemistry and Mineralogy
204 Deike Building

Degrees Conferred: Ph.D., M.S.

GEOCHEMISTRY

Graduate Faculty: Senior Members—Professors Bates, Brindley, Burnham, Greig, Griffiths, Keith, Muan, Osborn, Roy, Vand, Wickman, and Wright; Associate Professors Barnes, Dachille, Newnham, Thornton, Weber, and White; Mrs. Roy. Associate Members—Assistant Professor Rose; Messrs. Gold and Suhr.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOCHEMISTRY (GCHEM)

402. Introduction to Organic Geochemistry (3)
457. Geochemical Prospecting (2) *Mr. Barnes*

501. Research (1-10 per term) Research in geochemistry.

504. (F.Sc. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

509. Geochemistry Seminar (1 per term)

510. Problems in Geochemistry (1-9) Laboratory and library study of special problems.

512. Crystal Chemistry of Nonmetallic and Defect Solids (2-4) Relation of structure to ionic size, charge, polarizability; influence of p-t environment; chemical-structural defects, diffusion, transitions, and reactions in solids. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams.

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Weber*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Herzog*

518. Stable Isotope Geochemistry (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Mr. Weber*

519. Cosmochemistry and Nucleogenesis (2) Distribution and composition of matter; origin of solar system and earth, of constituent nuclides, of life. *Mr. Herzog*

520. P-T-X Phase Relations in Mineral Systems (2) Phase equilibrium in mineral systems with pressure as a variable. Prerequisite: Gchem. 513. *Mr. White*

522. Geochemistry of Aqueous Systems (3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, Po_2-pH relations applied to ground water, sea water, hydrothermal fluids. *Messrs. Barnes and Schmalz*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Mineral Sciences.*

GEOGRAPHY

Allan L. Rodgers, *Head of the Department*
403 Deike Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Deasy, Lewis, Miller, Rodgers, Wernstedt, and Zelinsky; Associate Professor Gould. Associate Members—Associate Professor Simkins; Assistant Professor Adams.

The student may concentrate on economic geography, cultural geography, physical geography, one of the major world regions, or acceptable combinations of these fields. In addition, all students receive training in cartographic, statistical, and bibliographic techniques.

Because physical geography is a branch of the physical sciences, and cultural and economic geography are branches of the social sciences, a student may enter graduate work under either of two options. Option 1, for the student who wishes to specialize in physical geography, requires the completion of 18 undergraduate credits in geography and 20 credits in mathematics and biological and physical sciences, including at least 6 credits in geology. Option 2, for the student who wishes to specialize in cultural or economic geography, requires 18 undergraduate credits in geography plus 20 credits in the social sciences, including at least 6 in economics.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Zelinsky*
402. Cultural and Anthropo-Geography (3) *Mr. Zelinsky*
405. Geography of Population (3) *Mr. Zelinsky or Mr. Simkins*
407. Geography of Settlement (3) *Mr. Williams*
410. Cartography—Map Design and Construction (3) *Mr. Deasy*
420. Urban Geography (3) *Mr. Adams*
427. Geography of the Soviet Union (3) *Mr. Rodgers*
428. Geography of Eastern Europe (3)
430. Agricultural Geography (3)
433. Regional Climatology (3) *Mr. Wernstedt*
434. Regional Physiography (3) *Mr. Lewis*
442. Geography of Europe (3) *Mr. Miller*
443. Geography of the Orient (3)
444. Geography of Africa (3) *Mr. Gould*
445. Geography of Southern Asia (3) *Mr. Wernstedt*
451. Map Interpretation (3)
452. Interpretation of Aerial Photographs (3) *Mr. Deasy*
456. Quantitative Methods of Geographical Analysis (3) *Mr. Gould or Mr. Williams*
460. Political Geography (3) *Mr. Lewis*

468. Transportation Geography (3) *Mr. Gould*
470. Industrial Location and Development (3)
480. Geography of Manufacturing (3) *Mr. Miller*
490. Physical Geography for Teachers: Landforms (3) *Mr. Lewis*
491. Physical Geography for Teachers: Regional Climatology (3) *Mr. Wernstedt*

500. Introduction to Geographic Research (3)

501. Geographic Bibliography (1) An introduction to the techniques of bibliographic search and the writing of research papers in geography. Prerequisite: Geog. 500.

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The literature of some phase of physical geography with emphasis on procedures for organizing material for classroom reports and discussions.

505. Economic Geography Seminar (3-12) The literature of some phase of economic geography with emphasis on procedures for organizing material for classroom reports and discussions.

506. Political Geography Seminar (3-6) The exploration of current problems and theory in political geography through critical discussion of the literature and original student research. Prerequisite: Geog. 460.

507. Development of Geographic Thought (1-6) Critical analysis of the growth of geographic thought from antiquity to the present; emphasis on structure of modern geography.

508. Cultural Geography Seminar (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.

509. Population Geography Seminar (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

510. Physical Geography Research (3-10) Original study in physical geography: a field problem or detailed library investigation with analysis and presentation of data.

511. Economic Geography Research (3-10) Original study in economic geography: a field problem or detailed library investigation with analysis and presentation of data.

512. Cultural and Political Geography Research (3-10) Original study in cultural and political geography: a field problem or detailed library investigation with analysis and presentation of data.

543. Conceptual Frameworks for Geographical Analysis (3) Critical analysis of structures of inquiry in geography: modeling, problems of causation, measurement, and ordering of spatial information.

GEOLOGY

Lauren A. Wright
Head of the Department of Geology and Geophysics
303 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Lattman, Ridge, Scholten, Spackman, Williams, and Wright; Associate Professor Schmalz. Associate Members—Associate Professors Dutcher, Parizek, and Traverse; Assistant Professors Guber and Voight.

Students may specialize in stratigraphy, paleontology, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, marine geology and chemical oceanography, coal geology, coal petrology, and geology of metallic and nonmetallic deposits.

Prerequisites for admission include 25 credits in an approved combination of chemistry, physics, mathematics, and biological sciences, and at least 18 credits in geology and mineralogy.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOLOGY (GEOL)

400.	Surface Geological Processes for Teachers (3)	
401.	Earth History for Teachers (3)	
402.	Field Methods for Teachers (3)	
410.	Structural Geology (3)	*Mr. Gold*
420.	(Bot. 420) Paleobotany (3)	*Mr. Spackman*
421.	Introduction to Coal Petrology (3)	*Mr. Williams*
423.	(Bot. 423) Introductory Palynology (3)	*Mr. Traverse*
430.	Paleontology (3)	*Mr. Guber*
440.	Marine Geology (3)	*Mr. Schmalz*
451.	Economic Geology (3)	*Mr. Ridge*
452.	Introduction to Hydrogeology (3)	*Mr. Parizek*
453.	Mechanics of Geological Materials (3)	*Mr. Voight*
461.	Geology of North America (3-6)	*Mr. Wright*
462.	Principles of Geomorphology (3-6)	*Mr. Lattman*
470.	Introduction to Field Geology (3)	*Mr. Wright*
472.	Field Geology (5)	*Mr. Dutcher*
481.	Geology of Oil and Gas (3)	*Mr. Scholten*
490.	Stratigraphy (4)	*Mr. Williams*

*500. Geology Seminar (1-9) Presentation, at weekly departmental meetings, of topics selected from geological literature.

†501. Stratigraphy (3-12) Principles of stratigraphic classification, lithofacies and biofacies, faunal zonation, correlation, sedimentation, and paleogeography, illustrated by stratigraphy of classical geologic regions: (a) Pre-Cambrian; (b) Paleozoic; (c) Mesozoic; (d) Cenozoic. Prerequisite: Geol. 430. *Mr. Williams*

†503. Paleontology (3-9) Morphology of animal groups significant for their

* Credits to be arranged, 1 to 6 per term.
† Credits to be arranged, 3 to 6 per term.

fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Guber*

504. History and Foundations of Geology (2-4) Theoretical aspects of geology; spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology. *Mr. Lattman*

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

515. Ore Microscopy (2-3) Theory and use of the ore microscope in identifying ore minerals in polished section, establishing paragenetic sequences, determining manner of deposition. *Mr. Barnes*

‡517. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Mr. Williams*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Messrs. Dutcher and Spackman*

526. (Bot. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Traverse*

530. Geological Problems (1-15) Prerequisite: 10 credits in geology and mineralogy.

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Parizek*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462. *Mr. Lattman*

551. Geotectonics (3-6) Tectonic principles and elements: nature and development of geosynclines, island arcs, mountain structures, stable masses, cratons, mobile belts. *Mr. Scholten*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and microscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

571. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

‡ Credits to be arranged, 2-3 per term.

590. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Mineral Sciences.*

GEOPHYSICS

Lauren A. Wright
Head of the Department of Geology and Geophysics
303 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Bell and Howell. Associate Members—Associate Professor Alexander; Assistant Professor Lavin.

Students may specialize in geophysical surveying, seismology, time-series analyses, geomagnetism, gravity, space applications of geophysics, tectonics, physical properties of rocks, radioactive age determinations, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects.

Students may be accepted with a B.S. or M.S. degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOPHYSICS (GPHYS)

400.	Physics of the Earth for Teachers (3)	
406.	Physics of the Earth (3)	*Mr. Howell*
407.	Well Logging (3)	
408.	Geophysical Surveying (3)	*Mr. Lavin*
415.	Gravity and Magnetic Surveying (3)	*Mr. Lavin*
416.	Electrical Surveying (3)	
417.	Seismic Methods (3)	*Mr. Lavin*
418.	Potential Theory Applied to Earth Problems (3)	*Mr. Alexander*

500. Geophysical Seminar (1 per term) Discussion of geophysical reports and papers; scientific outlook.

501. Research (1-10 per term) Research in geophysics.

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders. *Mr. Howell*

503. Special Studies in Geophysics (1-9) Special studies of the theories of geophysical methods.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting. *Mr. Alexander*

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth.

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration. *Mr. H. D. Wright*

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineral Sciences.*

GERMAN

Stanley R. Townsend, *Head of the Department*
105 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty: Senior Members—Professors Ebbinghaus, Shelley, Strelka, and Townsend. Associate Members—Professor de Levie; Assistant Professors Hohendahl and Kopp.

There is opportunity for major emphasis upon either literature or philology. Minimum qualifications for admission include 24 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies.

A thesis is required of all M.A. candidates in this major.

GERMAN (GER)

401. Advanced Stylistics (3)
430. History of the German Language (3)
443. (C.Lit. 443) Literary Relations of Germany with England and America (3-9)
454. Literature from the Age of Chivalry to the Thirty Years' War (3)
464. Literature from the Beginning of the Enlightenment Through Storm and Stress (3)
469. Goethe's Life and Works (3)
474. Classicism and Romanticism (3)
484. Literature from Realism to Expressionism (3)

*1G. Elementary German for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. Elementary German for Graduate Students (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. Bibliography and Research Techniques (3) Introduction to tools and

* No graduate credit is given for this course.

methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. Introduction to Middle High German (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. Readings in Middle High German (3) Intensive reading in Middle High German literature, especially of the *Blütezeit*. Prerequisite: Ger. 520.

522. Old High German (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. Gothic (3) Introduction to historical and comparative Germanic grammar; emphasis on the Gothic language and texts. Suitable for advanced students in English.

524. Old Saxon (3) Introduction to Old Saxon grammar; readings in Old Saxon texts, both prose and poetry. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

HIGHER EDUCATION

Robert E. Sweitzer
In Charge of Graduate Programs in Higher Education
113 Education and Psychology Center

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members—Professors Patrick, Sweitzer, and Wellington. Associate Member—Associate Professor Counelis.

Graduate work in the general field of higher education is offered for persons interested in the study of higher education and for persons preparing for administrative positions in colleges and universities. Academic emphasis and research may be carried out in the following areas: academic administration; institutional research; student personnel administration; financial management; and continuing education. Preparation for administration in various institutions, including community and junior colleges, is provided through alternative patterns of courses, internships, topical seminars, independent study, and research. The resources of the University, of cooperating institu-

tions, and of higher education agencies are utilized in preparing students to be able to integrate theory, practice, and research. Although each program option has a different emphasis and pattern, typically each student's program includes experiences dealing with the development and current nature of institutions of higher education, institutional administration, educational and/or philosophical foundations, research skills and computer programming, psychology and/or educational psychology, and social psychology or sociology.

The program is not available as a major to students who are preparing to give instruction in the arts, humanities, natural sciences, or social sciences. However, a minor program is available for those persons majoring in other departments and programs and who are interested in college and university teaching.

Although students with any undergraduate major may enter the program, degree requirements make certain prerequisites desirable. Requirements for admission to the M.Ed. program include a broad undergraduate background in the liberal arts and sciences, including a minimum of a B average in 14 credits above the freshman level in the social and behavioral sciences, and a minimum junior-senior academic average of B minus (2.75). Completion of the M.Ed. program requires a B average in approximately 36 graduate credits, 18 of which must be in 500-series courses, and internship or apprenticeship experiences in a minimum of two different administrative units.

Requirements for admission to the D.Ed. program include a minimum 3.25 average in a master's degree program, a broad liberal arts and science background with a minimum average of B for 24 credits in the social and behavioral sciences on the undergraduate and graduate levels. A minimum of two years' experience in institutions of higher education is also required, as is a satisfactory rating on the Miller Analogies Test or the Graduate Record Examination.

In addition to the Graduate School and College of Education requirements for the D.Ed. degree, the student is expected to maintain a 3.30 minimum grade average, provide evidence of work or internship experience in at least three different administrative units or areas, and earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree.

EDUCATIONAL SERVICES (ED SER)

545. Higher Education in the United States (2-3) Historical perspective and current status; development of functions and structures; issues in curriculum, admissions, government, administration, and finance.

546. The Principles of College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in Higher Education (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professional Education of Teachers (3) Development and present status of teacher education; objectives and standards; selection and guidance of students; personnel problems in relation to staff. Prerequisite: 6 credits in advanced courses in education and a course in educational psychology.

551. Student Personnel Programs in Higher Education (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

553. Student Personnel Administration Theory and Research (2-3) Relations of theory, practice, and research on administrative behavior and student personnel services; case study, role playing, programmed decision problems. Prerequisites: Ed.Ser. 551, 555.

555. Seminar in Higher Education (1-6) Special topics in higher education.

HISTORY

Robert K. Murray, *Head of the Department*
116 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members—Professors Brown, Dahmus, Forster, Hassler, Hoogenboom, Klein, McNall, Murray, and Thaden. Associate Members—Professor Green; Associate Professors Ameringer, Eggert, Frantz, Linker, Meier, Pixton, and Sun; Assistant Professors Borza, Enteen, Maddox, and Silverman.

Graduate work is offered in the following fields of history: ancient, medieval, early modern European, modern European, colonial American, 19th century American, modern American, British, Russian, Latin American, Far Eastern, Middle Eastern, political (European or American), diplomatic (European or American), economic (European or American), social and cultural (European or American), military (American), constitutional (European or American), and intellectual (European or American).

The candidate for the doctor's degree must pass examinations in three of the above fields, one of which is his dissertation field. He must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to his dissertation field. The candidate for the master's degree selects one broad field (such as modern European or American) for examination and thesis purposes. About half his course credits are selected outside the examination field. He also must take work in a cognate field. A thesis is required of all M.A. candidates in this major.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. All applicants must provide Graduate Record Examination scores with their applications.

All students are advised that individual instructors may require a reading knowledge of pertinent languages for seminar work and for research on thesis topics.

HISTORY (HIST)

401. Classical Civilization (3) *Mr. Borza*
403. The Middle Ages from Constantine to the Crusades (3) *Mr. Dahmus*
404. The Middle Ages from the Crusades to the Renaissance (3) *Mr. Dahmus*
408. Intellectual History of the Middle Ages (3) *Mr. Dahmus*
410. The Renaissance (3) *Mr. Green*
411. The Reformation (3)

413. The Age of Absolutism (3) *Mr. Green*
414. The French Revolution and the Napoleonic Era (3)
417. Nineteenth Century Europe (3)
419. Recent European History (3) *Mr. Forster*
422. History of the American Frontier (3) *Mr. McNall*
425. History of American Political Parties (3) *Mr. Hoogenboom*
426. The Diplomatic History of the United States to 1900 (3) *Mr. Maddox*
427. The Diplomatic History of the United States Since 1900 (3)
428. American Military History (3) *Mr. Hassler*
430. Colonial America to 1753 (3)
431. Revolutionary America, 1753-1783 (3) *Mr. Frantz*
432. The Formative Period of American History (3) *Mr. Brown*
433. The Middle Period of American History (3) *Mr. Klein*
434. The United States in Civil War and Reconstruction (3) *Mr. Hassler*
435. The Emergence of Modern America (3) *Messrs. Murray and Hoogenboom*
436. Recent American History (3) *Mr. Murray*
439. History of England in the Middle Ages (3) *Mr. Dahmus*
440. Britain Under the Tudors and Stuarts, 1485-1688 (3)
441. Great Britain, 1688-1832 (3) *Mr. Linker*
442. History of Russia to 1801 (3) *Mr. Thaden*
443. History of Russia, 1801-1917 (3) *Mr. Thaden*
444. Eastern Europe in Modern Times (3) *Mr. Thaden*
447. Social and Economic History of Europe Since 1750 (3) *Mr. Silverman*
448. Intellectual and Cultural History of Modern Europe (3) *Mr. Silverman*
449. Diplomatic History of Europe Since 1870 (3) *Mr. Forster*
452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
454. Economic Development of the United States (3) *Mr. Eggert*
456. History of American Labor (3) *Mr. Eggert*
458. Constitutional History of the United States to 1877 (3) *Mr. Stebbins*
459. Constitutional History of the United States Since 1877 (3) *Mr. Stebbins*
460. Latin America and the United States (3) *Mr. Ameringer*
461. Social and Cultural History of Latin America (3) *Mr. Ameringer*
467. Alexander the Great and the Hellenistic World (3) *Mr. Borza*
468. The Roman Republic (3) *Mr. Borza*
469. The Pax Romana (3) *Mr. Borza*
471. Nineteenth Century China (3) *Mrs. Sun*
472. Twentieth Century China (3) *Mrs. Sun*
480. The Medieval Middle East, 600-1800 (3) *Mr. Goldschmidt*
481. The Middle East in Modern Times (3) *Mr. Goldschmidt*
491. History of the Soviet Union (3) *Mr. Enteen*
492. Great Britain Since 1832 (3) *Mr. Linker*
497. Germany Since 1640 (3) *Mr. Silverman*
498. Selected Topics in History (3-6)

501. Historical Method (3) *Mr. Meier*

502. Historiography (3) *Mr. Meier*

504. Medieval Civilization (3-9) *Mr. Dahmus*

505. The Age of the Reformation (3-6) *Mr. Green*

507. Studies in European History, 1600-1750 (3-6)

508. Studies in European History, 1750-1900 (3-6) *Mr. Silverman*

509. Studies in Twentieth Century Europe (3-6) *Mr. Forster*

512. Studies in Pennsylvania History (3-6) *Mr. Klein*

520. Colonial and Revolutionary America (3-6) *Mr. Frantz*

533. The United States, 1783-1860 (3-6) *Mr. Klein*

534. The United States, 1860-1877 (3-6) *Mr. Hassler*

535. The United States, 1877-1919 (3-6) *Mr. Hoogenboom*

536. The United States Since 1919 (3-6) *Mr. Murray*

538. Diplomatic History of the United States (3) *Mr. Maddox*

539. Economic History of the United States (3) *Messrs. McNall and Eggert*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6) *Mr. Thaden*

545. Studies in Russian and Soviet History (3-6) *Messrs. Thaden and Enteen*

550. Problems in History (3-6)

552. Cultural History of the United States (3) *Mr. Brown*

562. Seminar in Latin-American History (3-6) *Mr. Ameringer*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Ameringer*

599. Readings in History (1-6)

HOME ART

William J. McHale, *Chairman of the Division of Home Art*
S-38B Human Development Building

A candidate for an advanced degree may choose a minor in home art upon approval by his major department. However, no advanced degree is offered in this field.

FAMILY HOUSING AND HOME ART (FH HAR)

401. Home Furnishings for the Family (3)
*433. Advanced Home Crafts (2-12)
440. Advanced Home Furnishing Problems (3)
441. Special Problems in Home Furnishings (3)
470. Housing Problems and Policies (3)

515. Backgrounds of the Home Arts (3) Evaluation of useful objects in respect to their form, function, and time; selections for exhibition.

530. Problems in Family Housing and Home Art (1-6) Individual investigation, analysis, and presentation.

541. Art in the Environment (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

* Not more than 2 credits in each field.

HOME ECONOMICS EDUCATION

MARJORIE EAST, *Head of the Department*
114 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors East and Hatcher. Associate Member—Associate Professor Ray.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

For admission the student must present approximately 50 credits of undergraduate work from the following areas: home economics education, education and/or psychology, aspects of home economics; the physical and biological sciences; and the social sciences.

HOME ECONOMICS EDUCATION (HE ED)

400, 400v. SPECIAL PROBLEMS IN HOME ECONOMICS EDUCATION (1-3)
406, 406v. AUDIO-VISUAL METHODS FOR HOME ECONOMICS (1-4)
410v. SUPERVISION OF STUDENT TEACHERS (1-3)
427, 427v. TEACHING HOME ECONOMICS (3)
443, 443v. ADULT EDUCATION IN HOME ECONOMICS (3)
463, 463v. SENIOR SEMINAR (2)
466, 466v. STUDENT TEACHING (9)
477, 477v. CURRICULUM DEVELOPMENT FOR HOME ECONOMICS IN SECONDARY SCHOOLS (3)
478, 478v. APPRAISING STUDENT PROGRESS IN HOME ECONOMICS (3)
479, 479v. READINGS IN HOME ECONOMICS EDUCATION (1-4)
480, 480v. PROBLEMS IN TEACHING HOME ECONOMICS (3-6)

502, 502v. HOME ECONOMICS INSTRUCTION AT THE COLLEGE LEVEL (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503, 503v. HOME ECONOMICS TEACHER EDUCATION (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504, 504v. EDUCATIONAL ISSUES AND HOME ECONOMICS (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510, 510v. EDUCATIONAL LEADERSHIP IN HOME ECONOMICS (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

511, 511v. INTERNSHIP IN HOME ECONOMICS SUPERVISION AND ADMINISTRATION (2-8) Opportunity to understudy an educational leader in student teacher supervision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE

Darrell E. Walker, *Head of the Department*
101 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members—Professors Hitz, Larson, Meahl, Odland, Ritter, Smith, Tukey, and Walker; Associate Professors Creech and McArdle. Associate Members—Professor Mastalerz; Associate Professors Bergman and Pfahl; Assistant Professors Craig, Haramaki, and White.

Students may specialize in propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various environmental and post-harvest physiological studies of horticultural crop species.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, plant nutrition, or pomology should register for Hort. 501.

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, and biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

HORTICULTURE (HORT)

401.	Plant Propagation (3)	*Mr. Haramaki*
402.	Plant Nutrition (3)	*Mr. Bergman*
403.	Horticultural Plants and Their Environment (3)	*Mr. Mastalerz*
404.	Advanced Horticultural Crop Science (3-12)	*Mr. Walker*
405.	Senior Seminar in Horticulture (1-2)	
407.	Plant Breeding (3)	*Mr. Creech*
412.	Post-Harvest Physiology (3)	*Mr. Ritter*
444.	Advanced Plant Breeding (3-6)	*Mr. Craig*
447.	Problems in Horticulture (1-9)	
451.	Flower Store Management (4)	*Mr. Pfahl*

500. Ecology of Fruit Plants (3) Factors limiting the distribution and intensity of culture of fruit species and varieties and effect of environmental factors on cultural practices. Spring term, even years. *Mr. Tukey*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology. *Mr. Walker*

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. Winter term, odd years. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Mr. Meahl*

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3) *Mr. Craig*

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years. *Mr. Tukey*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

INDUSTRIAL ARTS EDUCATION

John Withall, *Head of the Department of Secondary Education*
164 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Member—Associate Professor Pendered. Associate Member—Associate Professor Shemick.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

INDUSTRIAL ARTS (I ART)

400. Shop Management and Layout (3)
407. Curriculum Materials and Methods in Industrial Arts (4)
470. Problems in Senior High School Industrial Arts (3)

574. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. Problems in Industrial Arts Education (2-3) Subject matter, projects, methods of manual and informational teaching, aids and devices, selection of text

and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. Testing in Industrial Arts (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and grading; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. Seminar in Industrial Arts (2-9) Directed intensive study, investigation, or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING

Benjamin W. Niebel, *Head of the Department*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members—Professors Lancaster, Niebel, and Schmidt; Associate Professor Ham. Associate Members—Professor Thuering; Associate Professor Raphael; Assistant Professors Draper, Ermer, and Guild.

Graduate study and research are conducted in management science, production engineering, process design, systems engineering, and human engineering.

For admission a student must have a bachelor's degree in industrial engineering. Graduates of other accredited engineering majors may be admitted after completing basic work in industrial engineering.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
402. Engineering Economy (3)
403. Engineering Economy and Statistics (3)
404. Management Science (3)
405. Quantitative Methods in Industrial Engineering III (3)
406. Design of Production Systems (3)
422a,b,c,d,e,f. Industrial Engineering Problems (2-12)
423. Quality Control (3)
424. Job Evaluation (3)
425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Advanced Metal Casting (3)
428. Foundry Engineering (3)

430. Industrial Leadership (3)
432. Industrial Engineering Lectures (1-3)
438. Metal Cutting Principles and Practice (3)

501. Manufacturing Methods (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. Management Methods (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. Industrial Relations (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 43 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Budgetary Control and Standard Costs (3-6) Divisional budgets as control media; establishing standard cost data, standard cost accounting procedures, and the use of cost variances in controlling manufacturing operations. Prerequisite: I.E. 335.

508. Methods of Operations Research (3) Analytical approach to management decision-making including decision theory, game theory, constrained extremum theory; minimum cost transportation and network models. Prerequisites: Math. 100 and 3 credits in statistics.

509. Methods of Operations Research (3) Theory and application in decision-making including sequencing, line balancing, inventory, replacement, waiting line models, and Monte Carlo simulation. Prerequisites: Math. 100 and 3 credits in statistics.

510. Methods of Operations Research (3) Theory and application of mathematical programming including linear and dynamic programming, and an introduction to nonlinear, integer, and stochastic programming. Prerequisite: Math. 100.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 44 and 3 credits in statistics.

513. Data Processing and Programming (3) Theory and techniques in systems analyses applied to the programming of procedures and operations.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

JOURNALISM

VINCENT P. NORRIS, *In Charge of Graduate Programs in Journalism*
215 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty: Senior Member—Professor Brown. Associate Members—Professors Goodwin and Harrison; Associate Professors Froke, Norris, Pockrass, and Schulte; Assistant Professor Preston.

The program is designed to give students an understanding of the theory and practice of mass communication, a critical insight into the structure and functions of mass communications industries, an introduction to research on communications problems, and an opportunity to acquire some depth in a minor field of study. Fulfilling the requirements for this degree should qualify students to advance in positions of responsibility and leadership in the professions of journalism, advertising, broadcasting, and public relations; or in communications education and research.

The program is designed primarily for students who have had some professional courses or experience in journalism and mass communications. Other students will be required to complete a series of at least three undergraduate courses.

A thesis and a minor of 12 credits are required of all M.A. candidates in this major.

JOURNALISM (JOURN)

401. CRITICS AND ETHICS OF THE MASS MEDIA (3) *Mr. Harrison*
405. INTERNATIONAL MASS COMMUNICATIONS (3) *Mr. Schulte*
406. EVALUATION AND USES OF MASS COMMUNICATIONS RESEARCH (3) *Mr. Preston*
421. EDITORIAL INTERPRETATION (3) *Messrs. Harrison and Brown*
422. CULTURAL ASPECTS OF THE MASS MEDIA (3) *Mr. Pockrass*
424. PUBLIC AFFAIRS REPORTING (3) *Mr. Dulaney*
430. JOURNALISM IN THE SCHOOLS (3-6)
436. (Soc. 436) SOCIOLOGY OF OPINION FORMATION (3)
442. SPECIAL TOPICS IN ADVERTISING (3)
443. ADVERTISING CAMPAIGNS (3) *Mr. Rotzoll*
444. ADVERTISING IN CONTEMPORARY SOCIETY (3) *Mr. Norris*
466. PUBLIC RELATIONS PROBLEMS (3)
468. LAW OF MASS COMMUNICATIONS (3) *Mr. Smith*
481. NEWS EVALUATION AND PRESENTATION (3) *Mr. Harrison*
492. PUBLIC AFFAIRS BROADCASTING (3)
499. INDEPENDENT STUDY IN MASS COMMUNICATION (2-6) *Mr. Goodwin*

504. SEMINAR IN THE HISTORY OF MASS COMMUNICATION (3) *Mr. Schulte*

505. INTERNATIONAL COMMUNICATION PROBLEMS (3) Legal and communications problems of the international flow of news and opinion; international press codes.

506. SEMINAR IN COMMUNICATIONS RESEARCH (3-6) Methodology of research in media, content, audiences; experimental, case, and field studies; data processing and analysis; report writing; individual projects. *Mr. Preston*

508. THE LITERATURE OF JOURNALISM (3) *Mr. Brown*

513. CONSTITUTIONAL PROBLEMS OF THE NEWS MEDIA (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Goodwin*

540. Seminar in Advertising Problems (3) *Mr. Norris*

585. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*

MATHEMATICS

James B. Bartoo, *Head of the Department*
228 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members—Professors Anderson, Axt, R. Ayoub, Benton, Chowla, Fine, A. Frink, O. Frink, Hammer, Hunter, Kanwal, H. Krall, Mitchell, Mrowka, Patil, Ribeiro, Schoenfeld, and Sheffer; Associate Professors C. Andrews, Harkness, A. Krall, and Petrich. Associate Members—Professor Bartoo; Associate Professors C. Ayoub, Mack, M. McCammon, and Rung; Assistant Professors Bollinger, Comstock, Deutsch, Hahn, Hughes, Shapiro, and Stevens.

Graduate courses in all the principal branches of mathematics are offered each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, statistics, numerical analysis, applied analysis, and mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

To be admitted to the M.A. or Ph.D. program without undergraduate deficiency, an applicant should have completed at least three courses in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) *and* 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree.

For the M.A. degree the department offers two options:

(1) The *thesis* option requires 12 credits of 500-series courses, 6-9 credits of thesis, sufficient credits in approved 400-series courses to make a total of 30 credits, and a final (oral) examination based on the thesis and general course material.

(2) The *non-thesis* option requires 18 credits of 500-series courses in mathematics with grades of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic of mathematics. No final examination is given in this option.

All first-year students who are working toward the M.A. or Ph.D. degree are required to enroll in Math. 498 for two successive terms. All M.A. and Ph.D. students, before they have accumulated 48 graduate credits earned at this university or elsewhere, *must* take qualifying examinations in three fields of mathematics and a reading examination in French, German, or Russian. Recommendations for advancement to Ph.D. candidacy are based on these examinations. The comprehensive examination

is given after approximately 60 credits and only after the student has passed a reading examination in a second of the foregoing languages.

To be admitted to the M.Ed. program without undergraduate deficiency in mathematics, an applicant should have at least 24 credits in mathematics including at least 6 at the intermediate level beyond calculus.

For the D.Ed. degree, a student must pass a reading examination in French, German, or Russian before he is allowed to take the comprehensive examination. In addition to the major thesis, the department requires a minor thesis on an assigned topic in mathematics.

Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 415, 416, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. and D.Ed. degrees.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. (A.M. 405) Fourier Series and Partial Differential Equations (3)
407. Foundations of Algebra and Geometry (3)
409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
413-414. Mathematics of Science for Teachers (3 each)
415. Survey of Modern Mathematics for Teachers (3)
416. Mathematical Logic for Teachers (3)
417. (A.M. 417) Tensor Analysis (3)
418. (Stat. 418) Introduction to Probability Theory (3)
420-421. Introduction to Analysis (3 each)
428. (Phil. 428) Logical Theory (3)
431. (A.M. 431) Ordinary Differential Equations (3)
441. (A.M. 441) Matrix Algebra (3)
452. (A.M. 452) Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elementary Point-Set Topology (3)
480-481. Introduction to Modern Algebra (3 each)
491. Topics in Applied Mathematics (3-9)
498. Mathematics Seminar (1-6)

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisites: Math. 44, 421.

508-509. Complex Analysis (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

516. (Stat. 516) Intermediate Probability Theory (3) Random walk and recurrent events, Markov chains, and the simplest time-dependent stochastic processes. Prerequisite: Math. 418.

517-518. (Stat. 517-518) Advanced Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 501, 541.

520-521. Projective Geometry (3 each) General study of the subject from the postulational standpoint. Prerequisite: Math. 43. Alternate years or as required.

523. Metric Differential Geometry (3) The usual classical treatment of the subject. Prerequisite: Math. 43.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

529-530-531. Topology (2 each) Topological, product, compact, metric, and connected spaces; continuous functions, separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

533. Analytic Theory of Numbers (2-6) Topics selected from Dirichlet's Theorem on primes in A. P., Riemann Zeta-function, distribution of primes, Waring's problem, Goldbach's problem, partitions. Prerequisites: Math. 404 or 480; Math. 508.

534. Elementary and Algebraic Number Theory (2-6) The arithmetic and ideal theory of higher algebraic number fields will be emphasized, together with the necessary rational number theory. Prerequisite: Math. 480.

535-536-537. Algebra (2 each) Basic theory of semigroups and groups, rings and modules, fields, lattices, and linear algebra. Prerequisite: Math. 106.

538-539-540. Rings and Homological Algebra (2 each) Selected topics including structure theory of rings and an introduction to categories and functions. Prerequisite: Math. 537.

541. (Stat. 541) Mathematical Statistical Analysis (3) Probability spaces, random variables, distribution and characteristic functions, convergence theorems, univariate and multivariate distribution theory. Prerequisite: Math. 421.

542-543. (Stat. 542-543) Advanced Theory of Statistics (3 each) Exact and asymptotic sampling distribution theory, rigorous treatment of sufficiency, com-

pleteness, estimation, and testing. Prerequisites: Math. 410, 541.

544-545-546. General Topology (2 each) Topics selected including uniform spaces, function spaces, and proximity spaces. Prerequisite: Math. 531.

547-548-549. Lie Theory (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

550-551. (Phil. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. Numerical Analysis (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. Numerical Analysis (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420; Math. 454 or 481.

554. (Phil. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Math. 428.

556. (Phil. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions, recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 428.

557. (Phil. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisites: Math. 554, 556.

560-561. Theory of Differential Equations (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solutions. Prerequisites: Math. 100, 508.

562. Theory of Special Functions (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 100 and either Math. 420 and Math. 452 or Math. 508.

563. Approximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 501, 453.

564. Numerical Solution of Partial Differential Equations (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. (Stat. 577) Special Topics in Probability and Statistics (3-12)

578. Special Topics in Topology (3-12)

579. Special Topics in Numerical Analysis (2-12)

*580. Special Topics in Number Theory (2-12)

581-582-583. Group Theory (2 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 537.

584-585-586. Algebraic Topology (2 each) Development of singular and Cech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

587-588-589. Point Set Topology (2 each) Topics selected from point set topology including upper semicontinuous and continuous decompositions, theory of continua, dimension theory. Prerequisite: Math. 531.

MECHANICAL ENGINEERING

Richard G. Cunningham, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members—Professors Ambrosius, Brickman, Cunningham, DiIlio, McLaughlin, Meyer, Olson, Queer, Reethof, and Shearer; Associate Professor Schmidt. Associate Members—Associate Professors Brighton, DeCarolis, Heinsohn, Lestz, Park, Parke, Wolgemuth, and Zimmerman; Assistant Professors Baker, Bowlus, and Faeth.

Graduate programs and research facilities are available in dynamic system analysis and instrumentation, automatic controls, fluid amplifiers, combustion and ignition processes, heat transfer, thermodynamics, fluid mechanics, turbulence, machine dynamics, advanced design engineering, lubrication, power generation and utilization, and building research studies. In addition to basic facilities in the mechanical engineering laboratory, the department has several specialty research laboratories. They are: Systems and Controls Laboratory, Air Environment Laboratory, Dynamics Simulation Laboratory, and Automotive Safety Research Laboratory.

The entering student must hold a bachelor's degree in engineering or physical science. If his undergraduate work has not included considerable work in mechanical engineering subjects, he may be required to include these subjects in his program.

MECHANICAL ENGINEERING (M E)

401. Mechanical Engineering (3-12)

* Credits to be arranged, 2-3 per term.

402. Air Conditioning and Life Support Systems (3)
403. Rocket Propulsion (3)
405. Small Particle Technology (3)
409. Gas Turbines (3)
410. Power Plants (3)
411. Refrigeration (3)
412. Heat Transfer (3)
413. Internal Combustion Engines (3)
417. Theory of Engineering Instruments (3)
418. Principles of Turbomachinery (3)
421. (Aro.E. 421) Intermediate Viscous Flow (3)
422. (Aro.E. 422) Intermediate Inviscid Flow (3)
450. Design of Machine Tools (3)
451. Advanced Machine Design Problems (3)
452. Design Analysis (3)
453. Bearing Design and Lubrication (3)
455. Automatic Control Systems (3)
457. Advanced Mechanisms (3)

500. Special Topics in Thermodynamics (2-6)

503. Thermodynamic Process Analysis (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. Advanced Engineering Thermodynamics (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. Selected Topics in Mechanical Engineering (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Advanced Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions. Prerequisites: A.M. 451, M.E. 412.

513. Advanced Heat Transfer—Convection and Radiation (3) Convection heat transfer in laminar and turbulent flow; two-phase heat transfer, transportation, film and ablation cooling, and radiation heat transfer. Prerequisite: M.E. 412.

517. Special Topics in Transport Phenomena (2-6)

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.

521. Electromagnetic and Thermodynamic Flow Systems (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

522. Boundary Layer and Separated Flows (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.

540. Simulation of Mechanical Engineering Phenomena (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

551. Special Topics in Design and Controls (2-6)

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) Sliding and rolling surface phenomena; hydrostatic, hydrodynamic, and magnetohydrodynamic lubrication theory; design and control of gas and fluid lubricated bearings.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. Advances in Control Systems Analyses (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods.

557. Mechanism Synthesis (3) Design and analysis of mechanisms for specific motion and energy requirements; intermittent mechanisms. Prerequisite: M.E. 457.

558. Fluid Control Systems (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY

Robert W. Lindsay
In Charge of Graduate Programs in Metallurgy
221 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Lindsay, Muan, and Read; Associate Professors Healy, Hoke, Inman, and Ryba. Associate Members—Associate Professors Bitler and Simkovich.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree.

There is opportunity for a student to specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

To be prepared for the graduate program, the applicant should present a bachelor's degree in metallurgy or metallurgical engineering, or a satisfactory bachelor's degree in any other field which has included mathematics through ordinary differential equations; a year of basic physics; three courses in chemistry, including laboratory preferably, and covering inorganic chemistry and preferably physical chemistry. Students who lack some of this background can be admitted but will be expected to make up their deficiency without receiving graduate credit.

METALLURGY (METAL)

401. Metallurgical Processes and Kinetics (3)
402. Electrometallurgy, Hydrometallurgy, and Corrosion (3)
404. Pyrometallurgy (3)
405-406. Metallography (3 each)
407. Metallurgical Engineering I (3)
408. Metallurgical Engineering II (3)
410. Metallurgical Investigations II (2)
412. Solid-State Metallurgy (3)
459. Metallurgical Applications for Engineers (3)

501. Metallurgical Problems (1-6 per term) Independent study of special problems in metallurgy.

502. Seminar in Metallurgy (1-6) Conferences, reading, reports, and special lectures.

508. Kinetics of Phase Transformations (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. Introductory Theoretical Physical Metallurgy (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*

510. Magnetic and Transport Properties of Materials (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. Advanced Physical Metallurgy (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. Advanced Chemical Metallurgy I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Mr. Read*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 514. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513. *Mr. Lindsay*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 508, 511.

525. Metal Finishing (3) Metallic coatings and their metallurgical properties; theories and problems of application, utilization, and evaluation. Prerequisite: Metal. 515. *Mr. Read*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Mineral Sciences.*

METEOROLOGY

Alfred K. Blackadar, *Head of the Department*
502A Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Blackadar, Hosler, Neuberger, and Panofsky. Associate Members—Associate Professor Duquet; Assistant Professors Davis and Dutton.

Candidates may specialize in a variety of areas such as aerosol and cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, atmospheric optics and electricity, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

Requirements for admission include mathematics through differential equations and one year of college physics. Students with a strong background in mathematics, physics, or engineering may be admitted with deficiencies but must make up such deficiencies before they are admitted to candidacy for a degree.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
401. Physical Climatology for Teachers (3)
402. Biometeorology for Teachers (2)
403. Science Projects in Meteorology (1)
404. Physics of Weather Forecasting (3)
411. Introduction to Synoptic Meteorology (3)
418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meterology (3)
430. Introduction to Synoptic Meteorology Laboratory (3)
431. Synoptic Meteorology Laboratory I (3)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
443. Physical Meteorology (3)
445. Hydrometeorology (3)
450. Applications of Statistics to Meteorology (3)
451. Thermodynamics of the Atmosphere (3)
452. Hydrodynamics of the Atmosphere (3)
461. Theory of Meteorological Instruments (3)

472. Physical and Dynamic Climatology (3)
492. Meteorological Seminar (1-2)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Mineral Sciences.*

MICROBIOLOGY

Robert W. Stone, *Head of the Department*
206 Patterson Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Casida, Cone, Dunne, Gentry, Lindstrom, Ludwig, Stone, and Zimmerman. Associate Members—Associate Professor Heist; Assistant Professors Pootjes and Tershak.

Specialized areas of study include microbial physiology, soil microbiology, food and industrial microbiology, microbial genetics, immunology, bacteriophage, and virology. There is opportunity for cooperative research with other departments in animal dis-

ease, food technology, and waste disposal.

Prerequisites for admission are 20 credits in chemistry including quantitative analysis and organic chemistry, 6 in physics, 8 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work.

MICROBIOLOGY (MICRB)

401. General Microbiology (4)
407. Problems in Microbiology (1-12)
410. Immunology and Serology (4)
411. Survey of Microbiology (1 per term)
412. The Bacterial Pathogens (4)
413. Soil Microbiology (3)
414. Food Microbiology (4)
416. Industrial Microbiology (4)
417. Epidemiology (2)
418. Bacterial Viruses (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Physiology of Bacteria (2-4) Composition, nutrition, and growth of microorganisms; influence of physical and chemical environment on metabolism.

511. Special Topics in Microbiology (1-6)

512. Bacteriological Techniques (1-6) Practice in special laboratory techniques including manometry, tissue culture, and serology.

515. (V.Sc. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

516. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

MINERAL ECONOMICS

John D. Ridge, *Head of the Department*
101 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professor Ridge; Associate Professor Gordon. Associate Member—Assistant Professor Harris.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (fuels, metals, or nonmetals), resource economics (mineral policy or area studies), industrial economics (administration, market research, or financial analysis), or operations research and statistics (resource allocation, forecasting, or exploration programming).

The requirements for admission are 24 credits in chemistry, physics, mathematics, or statistics; 12 credits in the earth sciences; 9 credits in economics, mineral economics,

commerce, business administration, or industrial management; and 6 credits in engineering subjects.

Students having a deficiency of 9 credits or fewer in this total of 51 may be admitted as degree students but will be required to make up such deficiencies without the credits being applicable toward the advanced degree.

In addition to the normal degree requirements of the Graduate School, students receiving the M.S. degree must have a minimum of 9 credits of economics (including courses used for admission) and must pass an oral defense of their thesis. Doctoral candidates must complete at least 15 credits of economics (including courses used for admission). The comprehensive examination for the doctorate includes written examinations on the major and minor fields in addition to the oral examination required by the Graduate School.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. The Metals and Their Ores (3)
484. Economics of Energy Resources (3)
486. Petroleum and Natural Gas Economics (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (3)

500. Advanced Principles of Mineral Economics (3-6) Mineral history, research methods in mineral economics, applications of economic theory, mineral policy problems, economics of mineral exploitation, selected readings.

501. Advanced Studies in Mineral Commodities (3-6) Case studies of economic or industrial problems, or both, of selected mineral commodities. Prerequisites: 3 credits in Mn.Ec. 500 and at least 3 credits in Mn.Ec. 453, 483, 484, or 486.

502. Technologic Influences (3-9) Relationship of technologic advancements to economic development of the mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

505. Problems in Mineral Economics (3-12) Individual research involving library, laboratory, or field work to develop solutions to selected techno-economic problems of the mineral industries. Prerequisite: Mn.Ec. 500.

590. Mineral Economics Seminar (1 per term) Preparation and presentation of papers on advanced problems. Required each term in residence.

MINERAL PREPARATION

Harold L. Lovell, *Acting Head of the Department*
110 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Spicer and Sun; Associate Professor Lovell. Associate Member—Associate Professor McLean.

Areas in which students may specialize include the fundamentals of gravity, electrical, and chemical methods of beneficiating natural mineral deposits. Graduate work

may also be undertaken on the properties of specific minerals as they are related to beneficiation.

Graduates with a bachelor's degree in chemistry, physics, mathematics, mining, metallurgy, ceramics, fuel science, and chemical, mechanical, electrical, or civil engineering are eligible for admission. However, graduates in the above fields are required to take 6 credits in undergraduate courses in mineral preparation along with their graduate program.

MINERAL PREPARATION (MN PR)

401. Advanced Mineral Preparation Laboratory (1)
402. Mineral Preparation Seminar (1)
410. Coal Preparation (3)
420. Principles of Mineral Preparation Unit Operations (3)
421. Principles of Mineral Preparation Unit Operations (3)
425. Principles of Flotation (3)
426. Flotation Laboratory (1)
427. Modern Processes in Mineral Preparation (3)
430. Flowsheets of Mineral Preparation Plants (3)
457. Field Trip (1-2)

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 420. *Mr. Sun*

504. Mineral Preparation Research (1-6 per term) Research work on specific problems in mineral preparation. Prerequisite: Mn.Pr. 410 or 420.

505. Gravity Processes and Miscellaneous Methods of Mineral Preparation (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and dense-media processes of mineral concentration. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

506. Mineral Preparation Plant Design (3-10) Layout, design, and selection of equipment for specific mineral preparation plant projects. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

507. Chemical Processes of Mineral Preparation (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Mn.Pr. 420. *Mr. McLean*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineral preparation studies are listed under Mineral Sciences.*

MINERALOGY AND PETROLOGY

Arnulf Muan
Head of the Department of Geochemistry and Mineralogy
204 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Bates, Brindley, Burnham, Greig, Griffiths, Keith, Muan, Osborn, Roy, Vand, Wickman, and Wright; Associate Profes-

sors Barnes, Dachille, Newnham, Thornton, and Weber; Mrs. Roy. Associate Members—Assistant Professors Rose and White; Messrs. Gold and Suhr.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, mineralogy, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography. Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

MINERALOGY (MIN)

400. (Cer.Sc. 400) Nonmetallic Crystal Chemistry (2) *Mr. Brindley*
402. Mineralogy and Petrology for Teachers (3)
413. Scientific Method Applied to the Earth Sciences (3) *Mr. Griffiths*
463. Optical Mineralogy (3) *Mr. Gibbon*
483. Petrology (3) *Mr. Thornton*
484. Petrology (2) *Mr. Griffiths*

500. Optical Crystallography of Minerals (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Wright*

501. Petrology (3-6) Microscopic study of rocks, emphasizing classification and genetic relationships. *Messrs. Thornton and Griffiths*

502. Mineralogical Problems (3) Original study of some limited mineralogical or petrological problems.

505. Mineralogy Seminar (1-2) Reading, presentation, and discussion of literature dealing with various phases of theoretical mineralogy. Topics are selected to meet the interests of the majority of the students.

*510. Metamorphic Petrology (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484. *Mr. Burnham*

511. Sedimentary Petrology (3-4) Composition, texture, structure, mass properties of sediments; dynamic processes in complex natural systems; sedimentary stages: weathering, erosion, transport, deposition, lithification. Prerequisites: Min. 483, 484. Concurrent: Min. 513.

513. Methods of Analysis of Sediments (3) Principles and practices used in analyzing sedimentary rocks for size, shape, and accessory (heavy) minerals. Concurrent: Min. 511. *Mr. Griffiths*

514. Applied Sedimentology (3) Design and control in analysis of sedimentary rocks; application of these techniques to industrial problems. *Mr. Griffiths*

520. Study of Accessory Minerals (2-4) Detailed study of accessory (heavy) minerals; their significance in problems of provenance, petrogenesis, mineral stratigraphy, and paleogeography. Prerequisites: Min. 511, 513, 514. *Mr. Griffiths*

* Credits to be arranged, 2-4 per term.

524. Introduction to Sedimentation (3) Prerequisites: Min. 483, 484.

525. Igneous Petrology (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Mr. Burnham*

526. Statistical Problems in Sedimentary Geology (3) Application of experimental design, sampling procedures, multiple regression and discriminant analysis in solving problems in sedimentary petrography. Prerequisites: Min. 514; Math. 410 or Agro. 545. *Mr. Griffiths*

527. Igneous and Metamorphic Mineralogy (3) Structural and compositional variations of minerals in igneous and metamorphic rocks.

529. Radioactivity in Rocks (1-2) Distribution, mineralogy, and petrology of the radioactive elements. *Mr. Wright*

530. (Cer.Sc. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Mr. Brindley*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Mineral Sciences.*

MINING ENGINEERING

Robert Stefanko, *Head of the Department of Mining*
118 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Kochanowsky and Stefanko. Associate Members—Associate Professor Hardy; Assistant Professors Manula and Pariseau.

Areas of specialization which may be followed in research and course work include mine property valuation and economics of mining engineering (ore estimation, cost analysis and control, budgeting), mechanization and mine plant (unit operations, materials handling, continuous mining, power supply), development and exploitation methods (mine planning and layout, design of systems), mine management, production engineering and operations research (time study, standards, job rating, operations analysis), environmental control (gas and dust technology, ventilation, air conditioning, hygiene, illumination, safety), and rock mechanics (stress analysis, roof and ground control, penetration, fragmentation).

A bachelor's degree in mining engineering or a related engineering field is required for admission. Students may be required to make up deficiencies in their area of specialization. Certain basic, related courses outside the department may be approved as part of the major.

MINING (MNG)

402. Mine Plant Design (3)
410. Mining Engineering Analysis (3)
411. Mine Systems Engineering (3)
422. Mine Ventilation and Air Conditioning (3)

431. Rock Mechanics (3)
451-452. Advanced Mining Engineering I and II (1 each)

513. Mine Cost Analysis (3) Nature of mining costs, their analysis and control: depreciation and depletion, capital and operating costs, budgets, records.

514. Mine Operations Analysis (3) Application of operations research techniques in determining optimal design and operating policies for mine management. Prerequisite: Mng. 411.

515. Mine Systems Simulation (3) Principles and practices of probabilistic and deterministic simulation in the analysis of operating systems related to mills and mines. Prerequisites: Mng. 411, Cmp.Sc. 401.

525. Dust Technology (3) Physical and chemical properties of dusts; airborne dust determinations and analysis; dust control applicable to mills and mines. Prerequisite: Mng. 422.

531. Rheological and Strength Characteristics of Rocks (3) Properties of rocks and their determination; failure theories; brittle to ductile transition; rheological behavior. Prerequisite: Mng. 431.

532. Special Topics in Rock Mechanics (1-3) Behavior of rock under static loading; underground stress instrumentation; experimental stress analysis; design of mine openings; theories of subsidence.

533. Post-Yield Mechanics of Rock (3) Theory of inelastic, time-independent rock behavior; selected applications to drilling, blasting, mine opening, pit slopes, and ore passes. Prerequisite: Mng. 431.

541. Theory of Rock Penetration (3) Behavior of rock under dynamic loads intended to penetrate; basic energy relations; application of theory to drilling and other penetration. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. Rock Mechanics Instrumentation (3) Strain gage circuitry, transducers, electro-hydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Graduate Mining Seminar (1 per term) Preparation and presentation of formal papers on problems of an advanced nature in mining engineering. Required once during each year of residence.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mining studies are listed under Mineral Sciences.*

MUSIC

Robert W. Baisley, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members—Professor Henninger; Assistant Professor Brinsmaid. Associate Members—Professor Baisley; Assistant Professor Case.

The Master of Arts degree program is designed to provide a wide range of studies in music. The student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, history, and composition. Admission requires completion of a recognized music major. A thesis is required of all M.A. candidates in the program.

The Master of Fine Arts degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, auditions or submission of manuscripts are required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility.

MUSIC (MUSIC)

407. Piano Literature (3)
410. Music of the 20th Century (3)
411. A Chronological Study of String Literature (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
415. Hymnology (3)
416. Studies in American Music (3)
*‡429. Vocal Style (3) Fee $80.
433. The Singing Voice (3)
454. Harmonic Analysis (3)
455. Form and Analysis (3)
456. Counterpoint (3)
457. Composition (3)
459. Orchestration and Arranging (3)
466. Advanced Conducting (3)
467. Opera Workshop (1-6)
468. Advanced Chamber Music (1-6)

*‡501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

* Course may be scheduled only by conference with the head of the department.
‡ May be repeated for a total of 18 credits.

*‡503. Advanced Orchestral Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*‡511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*‡520. Voice (3) Study, repertoire building, and recital performance. Fee $80.

*‡531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on 20th century practices with attention to traditional idioms that serve as foundation.

544. Analysis and Analytic Procedures (3) Analytic studies for the development of effective understanding of modern musical syntax.

557. Symphonic Structure (3) Survey of the evolution and application of the forms used in symphony, sonata, concerto, string quartet, and related works. Prerequisite: Music 369.

*‡558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

567. The Literature of the Orchestra (3) The suite, symphony, tone poem, and overture from the point of view of appreciation, form, and orchestration.

570. History of Musical Instruments (3) A survey of the historical and morphological aspects of musical instruments.

571. Performance Practices (3) Analysis and performance of music of various periods based on manuscripts, documents, and other source materials.

599. Music Seminar (1-3) Seminar in the history, art, and science of music, with readings, discussion, and performance.

MUSIC EDUCATION

Frances M. Andrews, *Head of the Department*
264 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty: Senior Members—Professors Andrews and Dunlop. Associate Members—Professor Campbell; Assistant Professors Deihl and Fosse.

Graduate programs offer work in the various areas of public school music, including general, instrumental, and vocal/choral music on the elementary and secondary levels; preparation is also offered for supervisory or administrative positions, college teaching, and research. It is possible to include work from a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to certification, is a prerequisite for admission to the M.Ed. or D.Ed. programs. The latter also requires a minimum of two years of teaching experience.

* Course may be scheduled only by conference with the head of the department.
‡ May be repeated for a total of 18 credits.

MUSIC EDUCATION (MU ED)

415. Workshop in Selected Music Education Studies (1-6)
446. The Elementary Music Specialist (3)
462. Pedagogy of Theory (3)
468. The Teaching of Piano (3)
469. Band and Orchestra Technique (3)
470. Choral Technique (3)
471. Teaching Marching Band (2)
472. Wind Instrument Materials (2)
475. Objectives and Problems in Elementary Music Education (3)
480. Choral Program in the Secondary School (3)
487. Children's Songs and Records (3)

500. Music Education Seminar (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

501. Problems and Projects in Music Education (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. Proseminar: Graduate Study in Music Education (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.

569. Present-Day Trends in Instrumental Music (3) New methods and materials for band, orchestra, and ensembles.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

573. The Materials of Appreciation (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music, grades one through twelve.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

582. Theory and Projects in Musical Learning (3-6) Experimentation and self-instructional techniques involved in musical learning projects. Prerequisite: Inst.M. 435.

594. Pedagogy of Ear Training (3) Materials and methods for training the listener to grasp, understand, and write what is heard from melody to four-part harmony. Prerequisite: 12 credits in ear training and/or harmony.

599. Internship in Music Performance Techniques (1-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.

NUCLEAR ENGINEERING

Warren F. Witzig, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty: Senior Members—Professors Foderaro, Kline, and Palladino; Associate Professors Diethorn, Jacobs, and Remick. Associate Member—Assistant Professor D'Ardenne.

A student may specialize in reactor physics, neutron and radiation transport phenomena, thermal and mechanical design of reactors, supervision and utilization of research reactors, nuclear materials, or reactor instrumentation and control. Admission requires a bachelor's degree in engineering or in the physical sciences. Students who have not had appropriate undergraduate courses in modern physics and differential equations will be required to schedule them.

NUCLEAR ENGINEERING (NUC E)

401. Introduction to Nuclear Engineering (3)
410-411. Nuclear Engineering (3 each)
420. Radiological Safety (2)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 411.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 100.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

511. Nuclear Reactor Materials (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

550. Special Topics in Nuclear Engineering (1-12) Theoretical studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 44, Phys. 406.

PETROLEUM AND NATURAL GAS ENGINEERING

C. Drew Stahl
Head of the Department of Petroleum and Natural Gas
26 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Slobod and Stahl; Associate Professors Bissey and Burcik. Associate Members—Assistant Professors Donohue and Farouq-Ali.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

Students who expect to enter graduate study in this field with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission.

Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

PETROLEUM AND NATURAL GAS (P N G)

410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)

485. Engineering in Secondary Recovery (3)
493. Engineering Evaluation of Oil and Gas Properties (3)
495. Formation Evaluation (3)

510. Flow of Homogeneous Fluids Through Porous Media (3) Applications of vectors, separation of variables, conformal mapping, Laplace transform to describe steady and unsteady state flow in porous media.

511. Material Transfer in Porous Media (3) Diffusion and convective mixing in porous media; solution of the partial differential equations involved; difference methods; mathematical model, viscous instabilities.

512. Reservoir Engineering (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

517. Case Studies of Secondary Recovery (1-3) Interpretation and critical analysis of production and injection characteristics of typical water flood operations. Prerequisite: P.N.G. 515 or 485.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

525. Special Topics in Petroleum Engineering (2-6)

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.

*535. Seminar (1-3)

540. Special Studies in Petroleum Engineering (1-3) Supervised short study performed in the field, library, or laboratory covering any approved topic related to petroleum engineering.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Mineral Sciences.*

PHILOSOPHY

John M. Anderson, *In Charge of Graduate Programs in Philosophy*
417 Boucke Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members—Professors Anderson, Finch, Freund, Hausman, Johnstone, Mourant, and Rosen; Associate Professors Gotshalk and Lingis. Associate Members—Associate Professors Price and Tsugawa; Assistant Professor Allison.

* Credits to be arranged, 1 per term.

A thorough grounding in the history of philosophy is required of all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics and social philosophy, logic), in movements of thought (such as rationalism, empiricism, idealism, phenomenology, existentialism), or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics. Undergraduate preparation to the extent of a strong minor is advisable.

The department may waive the requirement of a thesis for an M.A. candidate.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
408. Studies in Social and Political Philosophy (3)
410. Studies in Greek Philosophy (3-6)
411. Studies in Modern Philosophy (3-6)
412. Studies in Contemporary Philosophy (3)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)
417. Nineteenth Century Philosophy (3)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Classics of Scientific Method (3)
422. Philosophical Logic (3)
426. Metaphysics (3)
427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (1-9)
435. Religion and Science (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

507. Seminar in Medieval Philosophy (3-6) Study of one or more important men or movements in medieval philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the 19th century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in 20th century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in 19th Century Philosophy (3-6) Study of a philosopher or philosophical movement of the 19th century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550-551. (Math. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Phil. 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions, recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Phil. 428.

557. (Math. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisites: Phil. 554, 556.

PHYSICAL EDUCATION

Benjamin H. Massey
Associate Dean for Graduate Study and Research
238A Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Buskirk, Conger, Coombs, Gross, Harnett, and Massey. Associate Members—Associate Professors Magnusson, Nelson, and van der Smissen; Assistant Professors Kollias and Morehouse.

Areas of specialization include (1) physiology of exercise (physical conditioning, physical fitness, and performance stress); (2) kinesiology (applied anatomy and biomechanics); (3) measurement and test construction; (4) cultural bases of physical education and sport (history, philosophy, and sociological foundations); (5) motor learning; (6) organization and administration (methods and materials, curriculum construction, intramurals, and interscholastics); and (7) recreation and parks.

Admission to the M.S. program requires a major in physical education or its equivalent in comparable course work. Especially desirable is course work in mathematics plus a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended areas of specialization. Admission to the M.Ed. program requires a minimum of 18 credits in health and physical education plus 18 credits in education and educational psychology combined, including practice teaching. A year or more of field experience is recommended.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable performance on the Aptitude Test of the Graduate Record Examination or other specified tests. A student who has earned a master's degree in recreation and parks and meets the above requirements may enter a doctoral program in physical education with specialization in recreation and parks.

See also "Recreation and Parks."

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)

501. Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

PHYSICAL EDUCATION (PH ED)

400. Adaptive Physical Education (3)
452. Analysis of Physical Education Activities for the Elementary School (3)
455. Scientific Method in Health and Physical Education (3)
460. Methods and Principles of Athletic Coaching (3)
480. Advanced Anatomy and Physiology, Applied (3)
489. Intramural Athletics (3)
490. Introduction to Tests and Measurements in Health and Physical Education (3)
491. Organization and Administration of Health and Physical Education in Schools (3)

500. (Rc.Pk. 500) Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

530. (Rc.Pk. 530) Research Techniques in Health and Physical Education and Recreation (3)

531. Research in Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

536. Scientific Methods in Athletic Coaching (3) Unusual techniques in athletic coaching which are not commonly recognized and used; advanced skills and strategy in coaching major sports. Prerequisite: Ph.Ed. 460.

550. (Rc.Pk. 550) Seminar in Health and Physical Education and Recreation (1-6)

555. Relationships of Physical Education to the Exact Sciences (3)

560. Administrative Problems of Physical Educational in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education into the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

581. Problems in Body Mechanics (3) Certain aspects of human motion and body segmental alignment; analysis of human gait, and the dynamic adaptation of the spine, thorax, and pelvis to external physical forces. Prerequisites: Hl.Ed. 244, Ph.Ed. 400.

582. Advanced Kinesiology (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments. Prerequisite: Hl.Ed. 244.

585. (Phsio. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Phsio. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Phsio. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.

595. Philosophy of Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICAL SCIENCE

Henry W. Knerr
Chairman of the Committee on Physical Science
101 Willard Building

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, includes at least 24 credits in physical science chosen from chemistry, earth sciences, mathematics, and physics and a minor of at least 6 credits in education. A candidate is required to earn at least 15 credits in chemistry and physics with a minimum of 6 in each, and at least 3 credits each in earth sciences and mathematics. The completion of a satisfactory term paper and a course in integral calculus is also required.

For admission to the M.Ed. program a student is expected to have completed at least one year each in college chemistry and college physics, mathematics through trigonometry, and 18 credits in education and related psychology. For admission to the D.Ed. program a course in integral calculus is also required.

The D.Ed. program requires a minimum of 60 credits in physical science, of which 24 may be in courses designed specifically for teachers. At least 12 credits each in

chemistry and physics must be selected from standard courses at the 400 and 500 level. A minimum of 15 credits each is required in professional education and thesis research. The thesis may be based on an experimental study in chemistry or physics or on the study of a problem in the teaching of physical science.

See also "Earth Sciences," "Chemistry," "Mathematics," and "Physics."

PHYSICS

David H. Rank, *Head of the Department*
101 Osmond Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Bleuler, Brickwedde, Frankl, Gibbons, Kazes, Knerr, McCubbin, McKelvey, Müller, Polo, Pratt, Rank, Schilling, Skudrzyk, Webb, and Wiggins; Associate Professors Atwater, Cutler, Herman, Kendall, Strother, Weber, and Whitfield. Associate Members—Associate Professors Feuchtwang, Schumacher, and Thwaites; Assistant Professors Eastman, Fleming, Freed, Graetzer, and McCammon.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, laser physics, solid state, field emission, acoustics, high-pressure physics, low-temperature physics, nuclear physics, physics of high polymers, electron spin resonance of solids, and various phases of theoretical physics.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including Phys. 400 and 458 and approved laboratory work such as Phys. 470; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
412. Introduction to Solid State Physics (3)
419. (A.M. 419) Theoretical Mechanics (3)
420. Classical Thermodynamics (2)
421. Thermal Physics (2)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
436. Optics for Teachers (3)
437. Heat, Wave Motion, and Sound for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
441. Demonstration Experiments for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)

456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. (A.M. 461) Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)

507. Thermodynamics (3) Classical thermodynamics and thermodynamics of irreversible processes. Prerequisites: Phys. 420, Math. 417.

509. Physics Seminar (1-3 per term) Topics from current research.

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 507, 561.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle; canonical transformation; Lagrange and Poisson brackets; Hamilton-Jacobi equations; classical theory of field. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and visco-elastic media. Prerequisite: Phys. 530.

550. (A.M. 550) Applied Group Theory (3) Representations of discreet and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

560. Research Problems (1-10) Introduction to research through individual assignments.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

575. Special Topics (1-3 per term) Theoretical studies in any field of modern physics with or without associated experimental work. Prerequisite: Phys. 456.

PHYSIOLOGY

Richard D. Schein
Chairman of the Committee on Physiology
211 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

This is an interdisciplinary program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal science, biochemistry, biophysics, and zoology, and the Human Performance Research Laboratory. The instructional staff is composed of the program committee as well as faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cellular and subcellular physiology, environmental physiology, endocrinology, applied physiology (human performance), physiology of nutrition and metabolism, neurophysiology, or comparative physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements.

The following courses are available for physiology majors, and their descriptions may be found under the offerings of several departments: Anthy. 401; A.Ntr. 401, 402; Bioch. 401, 402, 417, 436, 437, 501, 517, 519, 520, 521; Bphys. 473, 474, 475, 580; D.Sc. 427, 431, 512, 515, 521; F.N. 452, 457, 459, 552, 557; Micrb. 401, 508; Psy. 402, 403, 503; V.Sc. 400; and Zool. 401, 471, 541, 583.

PHYSIOLOGY (PHSIO)

501. Seminar (1 per term)

510. Special Topics in Physiology (1-6)

571. (Zool. 571) Animal Physiology (2) Physiology and fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Zool. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Zool. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Zool. 574) Animal Physiology Laboratory (3) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, ex-

cretion, respiration, metabolism, and neuroendocrines. Prerequisites: Phsio. 571, 572. Prerequisite or concurrent: Phsio. 573.

585. (Ph.Ed. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Ph.Ed. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Ph.Ed. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Phsio. 585.

PLANT PATHOLOGY

James Tammen, *Head of the Department*
111 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Bloom, Boyle, Kneebone, Lewis, Mills, P. E. Nelson, R. R. Nelson, Tammen, and Wernham; Associate Professor Wood; Assistant Professor Merrill. Associate Members—Professor Hyre; Associate Professor Schisler; Assistant Professors Lukezic and Wuest.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology, and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. It is strongly recommended, but not required, that an applicant have 3-6 credits in a foreign language. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

PLANT PATHOLOGY (P PATH)

408.	Plant Pathological Techniques (3)	*Mr. Bloom*
410.	Intermediate Plant Pathology (1)	*Mr. Wuest*
411.	Diseases of Ornamental and Floricultural Plants (2)	*Mr. Nelson*
412.	Advanced Forest Pathology (2)	*Mr. Merrill*
413.	Diseases of Field Crops (2)	*Mr. Lukezic*
414.	Diseases of Fruit and Vegetable Crops (2)	*Messrs. Bloom and Boyle*
429.	Phytonematology (3)	*Mr. Bloom*

501. Clinical Plant Pathology (3) Advanced course in diagnostic techniques to acquaint the students with specialized procedures for field and laboratory identification of plant diseases. Prerequisites: P.Path. 10, 408, Bot. 419. Summer term, odd years.

510. Advanced Plant Pathology (3) Principles of plant disease development; emphasis on physiology of suscept-pathogen interactions and on development of epiphytotics. Prerequisites: P.Path. 410, Bot. 419. Winter term, odd years.
Mr. R. R. Nelson

515. Disease Resistance in Plants (2-4) Stability of resistance, selection of resistant material, economics of control, special problems. Prerequisites: Bot. 22 or 33, P.Path. 10. Fall term, odd years. *Mr. Wernham*

518. Special Problems (1-12) The prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

519. Virus Diseases of Plants (3) Nature, symptomatology, transmission, and control of virus diseases of plants. Fall term, even years. *Mr. Boyle*

520. Plant Pathogenic Bacteria (3) Bacteria causing plant diseases; methods of identification, inoculation, and control. Spring term, odd years. *Mr. Kneebone*

530. Plant Disease Control (3) Methods, and laboratory and field testing of materials used in plant disease control. Spring term, even years. *Mr. Cole*

531. Plant Pathology Seminar (1 per term) Selected topics of current research, history, and contemporary trends in plant pathology. *Mr. Tammen*

POLITICAL SCIENCE

Bernard C. Hennessy, *Head of the Department*
129 Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Aspaturian, Atwater, Hennessy, Masters, McGeary, Monat, Mowitz, and Silva; Associate Professor Albinski. Associate Members—Associate Professors Kochanek and Pettit; Assistant Professor Leduc.

Students may specialize in American politics, comparative politics, international relations, political philosophy, or public administration. Doctoral candidates must undertake course work in empirical theory and scope and methodology.

Applicants for admission will be expected to have at least 12 credits in political science or its equivalent. In exceptional cases students may be permitted to make up deficiencies after beginning their graduate programs.

The department offers both a thesis and a non-thesis plan for the M.A. degree.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Messrs. Keynes and Masters*
403. The Legislative Process (3) *Messrs Keynes, Masters, and Pettit*
411. American Political Theory (3) *Messrs. Eisenach and Ricci*
412. International Organization: Economic and Social Welfare Functions (3) *Mr. Atwater*

413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian and Atwater*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*
415. International Organization: Political and Security Functions (3-6) *Messrs. Aspaturian and Atwater*
416. International Law (3)
417. American Local Government and Administration (3) *Mr. Leduc*
419. Bureaucracy and Public Policy (3) *Messrs. Monat and Lee*
421. Modern Political Theory (3) *Messrs. Eisenach and Ricci*
426. Political Parties (3) *Miss Silva*
427. Political Opinion and Propaganda (3) *Miss Silva, Messrs. Hennessy and Pettit*
431. Ancient and Medieval Political Theories (3) *Messrs. Ricci and Eisenach*
433. The Law of Labor-Management Relations (3) *Mr. Boyan*
442. American Foreign Policy (3) *Mr. Atwater*
444. Government Regulations (3) *Messrs. Hennessy and Ferguson*
445. Administrative Law (3) *Mr. Boyan*
447. Constitutional Law: The Federal System (3) *Miss Silva*
448. Constitutional Law: Government and the Individual (3) *Mr. Boyan*
449. Anglo-American Legal Systems (3) *Messrs. Eisenach and Keynes*
450. Canadian and Australian Politics and Foreign Policies (3) *Mr. Albinski*
451. Comparative Political Analysis (3) *Mr. Albinski*
453. Politics and Institutions of Developing Areas (3-6) *Messrs. Kochanek and LaPorte*
456. Politics and Institutions of Latin-American Nations (3) *Mr. Petras*
457. International Politics of Latin America (3-6) *Mr. Petras*
458. Governments and Foreign Policies of the Far East (3-6) *Mr. Kochanek*
459. Government, Politics, and International Relations of South Asia (3) *Mr. Kochanek*
499. Foreign Study in Government (2-6)

500. Political Power (3-6) Subject to be announced.

505. Executive Power (3-6) *Miss Silva, Messrs. Ferguson and Monat*

509. Scope and Method of Political Science (3-6) *Mr. Pettit*

512. Comparative Political Systems (3-9) *Messrs. Albinski and Kochanek*

513. Seminar in Comparative Political Parties (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Mr. Albinski*

515. International Politics (3-6)

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

518. Latin-American Politics (3-6) Forces which shape the quest for power and the process by which public policies are determined.

521. Modern Democratic Political Theory (3-6)

522. Comparative Foreign Policies (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Mr. Aspaturian*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-

making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

527. Politics and Legislative Behavior (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Messrs. Masters and Pettit*

528. Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies. *Mr. Masters*

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form. *Messrs. Ferguson and Monat*

530. Public Law (3-6) The nature of law and its role in modern society. *Miss Silva*

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Mr. Aspaturian*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought.

571. Theory of Public Administration (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Mowitz*

572. International Development Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. LaPorte*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. LaPorte*

574. Seminar in the Administration of United States Foreign Affairs (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Mr. LaPorte*

575. Government Manpower Management (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline. *Mr. Lee*

576. Government Fiscal Decision-Making (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *Mr. Monat*

577. Organization and Systems Management (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Mowitz*

578. Public Planning and Development Administration in the United States (3) Public planning agencies and their functions; essentials of effective planning and zoning; current trends and problems. *Mr. Leduc*

580. Internship in Public Administration (6)

POULTRY SCIENCE

KENNETH GOODWIN, *Head of the Department*
103 Weaver Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Bressler, Buss, Goodwin, Hale, and Mueller; Associate Professor Hicks. Associate Member—Associate Professor MacNeil.

The department offers two types of graduate programs. Students interested in genetics or physiology may participate in these programs with thesis research in the Department of Poultry Science. (See "Genetics" and "Physiology" for admission requirements.)

The programs in behavior, food technology, management, and nutrition consist of a major in poultry science and a minor in one or more other fields of science. Admission requirements include 30 credits in biology, chemistry, mathematics, and physics.

POULTRY SCIENCE (PTY SC)

401. (Psy. 401, Zool. 401) ANIMAL BEHAVIOR (3) *Mr. Hale*

402. SPECIAL TOPICS (3-12)

405. POULTRY PRODUCTION TECHNOLOGY (3) *Mr. Mueller*

502. ADVANCED POULTRY NUTRITION (2-4)

503. ADVANCED POULTRY FARM MANAGEMENT (2-4) *Mr. Bressler*

504. ADVANCED MARKET POULTRY AND EGGS (2-4) Prerequisites: Fd.T. 202 and 2 additional credits in poultry science. *Messrs. Mueller and MacNeil*

505. RESEARCH IN POULTRY SCIENCE (1-10 per term) Prerequisite: 9 credits in poultry science.

582. (Psy. 582, Zool. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale and Schein*

NOTE: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

PSYCHOLOGY

MERRILL E. NOBLE, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.S.

Graduate Faculty: Senior Members—Professors Carpenter, Ford, Greenhill, Guthrie, Hall, Harris, Hoffman, Leibowitz, Lundy, Mitzel, Noble, Palermo, Smith, VanOrmer, and Warren; Associate Professors Gorlow, Schipper, Seibel, Sherif, Thevaos, and Urban. Associate Members—Professor Taylor; Associate Professors Dubin, Piers, and Whaley; Assistant Professors Ashby, Cornwell, Freeman, Galbraith, Stern, and Thomas.

PSYCHOLOGY

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, measurement and statistics, social and personality, developmental, clinical, industrial and business, engineering and human factors.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computation Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a junior-senior scholastic average of B, a minimum of 12 credits in psychology, a satisfactory graduate student rating on the Miller Analogies Test, and the Graduate Record Examination (General). Applicants with a master's degree will have their admission evaluated with emphasis on the quality of their graduate program.

PSYCHOLOGY (PSY)

401.	(Pty.Sc. 401, Zool. 401) Animal Behavior (3)	*Mr. Hale*
402.	Sensation and Perception (3)	*Mr. Freeman*
403.	Introductory Physiological Psychology (3)	*Mr. Warren*
404.	Learning and Motivation (3)	*Mr. Hall*
405.	The Experimental Psychology of Visual Perception (3)	*Mr. Leibowitz*
406.	Experimental Social Psychology (3)	
408.	Comparative Psychology (2-4)	*Mr. Warren*
410.	History of Psychology (3)	*Mr. Leibowitz*
412.	Abnormal Psychology (3)	
413.	Biographical Psychology (3)	*Mr. Harris*
415.	Intermediate Experimental Design (3)	
417.	Social Psychology (2-3)	
422.	Psychological Methods of Measuring the Reactions of the Public (3)	
425.	Psychology of the Elementary School Child (2-3)	*Mr. Whaley*
426.	Adolescence (2-3)	*Mr. Harris*
427.	Psychological Principles in Advertising (3)	
428.	Opinion Research Laboratory (3)	
430.	Verbal Behavior and Verbal Learning (3)	*Mr. Cofer*
431.	Industrial Psychology (3)	*Mr. Smith*
432.	Introductory Engineering Psychology (3)	*Mr. Schipper*
433.	Psychology of Occupational Behavior (2)	*Mr. Dubin*
436.	Mental Health in Schools (3)	
437.	Psychology of Adjustment (3)	*Mr. Gorlow*
438.	Theory of Personality (3)	*Mr. Gorlow*
440.	Psychology Projects (1-6)	
441.	Industrial Motivation and Morale (3)	
445.	(C.D.F.R. 445) Development Throughout Adulthood (3)	*Mr. Britton*
450.	(Ed.Psy. 450) Principles of Measurement (3)	
474.	Psychology of Exceptional Children (3)	*Miss Piers*
482.	Introduction to Clinical Psychology (3)	*Mr. Galbraith*

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

501. Advanced Psychology (3) Comprehensive study of general psychology. Prerequisite: 9 credits in psychology.

503. Physiological Psychology (2-6) Correlations between structure and function of nervous system and human consciousness; laws and theories in fields of sensation, attention, association, affection, and thought. Prerequisite: 9 credits in psychology. *Mr. Warren*

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psychology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 or Ed.Psy. 421.

511. Seminar in Contemporary American Psychology (2-3) Current systems or schools of psychology with comparative study and critical analysis; points of view as presented by recognized leaders. Prerequisite: 9 credits in psychology.

515. Advanced Statistics in Psychology and Education (3) Correlation theory and methods, discriminant function, and factor analysis; applications to mental test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

518. Projects in Experimental Psychology (2-4) Individual experimental projects; seminars on experimental design and instrumentation.

527. Statistical Inference and Experimental Design (3) Probability theory, sampling distributions, analysis of variance and covariance, analysis of trend, nonparametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

528. Opinion Research Administration (1-6) Practicum in planning, development of techniques, and administration of the sample survey. Prerequisites: Psy. 15, 21, 422.

529. (C.D.F.R. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisite: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

535. Human Development (2-3) Psychological phases of human development throughout the life span; implications for school, community, and home. Prerequisite: 9 credits in psychology.

536. (C.D.F.R. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

537. Seminar in Industrial Psychology (3) Prerequisite: Psy. 431. *Mr. Smith*

538. Psychology of Personnel Development (3) Industrial training in relation to psychological learning theory and experimental findings. Prerequisite: Psy. 431 or Ed.Psy. 421. *Mr. Smith*

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct, drive, motive, will, purpose; methodology and results of physiological, experimental, and clinical investigation of basic drives. *Mr. Hall*

540. Seminar in Clinical Problems (1-6) Contemporary psychological theory, research, and methodology in relation to clinical psychology. Prerequisites: Psy. 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality and relevant research with emphasis upon normal processes. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference to clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (3)

549. (C.D.F.R. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

555. Theory and Practicum in Clinical Assessment (3) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

556. Theory and Practicum in Clinical Assessment of Pathological Syndromes (3) Current research and theoretical issues in the clinical assessment of pathological syndromes; includes practicum. Prerequisite: Psy. 555.

558. Clinical Child Psychology (3) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 425, 426, 555, 561.
Miss Piers

559. The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment; includes principles of school psychology. Prerequisites: Psy. 425, 426, 555.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-6) Practical experience in the Psychology Clinic in advanced nondirective therapy techniques; staff meetings; case conferences.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Pty.Sc. 582, Zool. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.
Messrs. Hale, Schein, and Warren

590. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION

Robert J. Mowitz
Director of the Institute of Public Administration
302 Engineering E

Degree Conferred: M.P.A.

Graduate Faculty: Senior Members—Professors Hennessy, Masters, Monat, Mowitz, and Silva. Associate Members—Associate Professor Pettit; Assistant Professors Leduc and Westby.

All candidates take a core program and may concentrate through electives in one of the following areas: general public administration, municipal management and public planning, or international development administration.

Candidates for admission ordinarily will have at least 12 hours of undergraduate credit in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

RECREATION AND PARKS

Benjamin H. Massey
Associate Dean for Graduate Study and Research
238A Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Coombs, Gross, and Massey. Associate Members—Associate Professors Nelson and van der Smissen.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Areas of specialization include (1) recreation and park administration, including outdoor recreation planning, (2) recreation program supervision and administration, including recreation for special groups, (3) camping, outdoor education, and outdoor interpretive services, and (4) professional education.

The master's degree may be earned in the major field of recreation and parks. At the doctoral level, attention is called to the programs available in the physical education major.

For admission to the graduate program, a bachelor's or master's degree is required in recreation, park administration, or in a related field; e.g., forestry, landscape architecture, sociology, psychology, physical education, education, fine arts.

RECREATION AND PARKS (RC PK)

420. Outdoor Recreation (3)
430. Outdoor Education (3)
456. Recreation Program Organization (3)
461. Community Recreation (3)
465. Administration of Recreation and Parks (3)
470. Metropolitan Park Management (3)
475. Recreation for Special Groups (3)

500. (Ph.Ed. 500) Individual Study and Research Projects (1-10) Prerequisite: Rc.Pk. 530.

515. Program Development and Supervision (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstra-

tion projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.

520. Seminar in Camp Administration (3) Values inherent in the camp experience; critical analysis of philosophical choices and sponsor objectives as influencing program development. Prerequisite: Rc.Pk. 230 or 430.

530. (Ph.Ed. 530) Research Techniques in Health and Physical Education and Recreation (3)

533. Recreation Studies, Surveys, and Appraisals (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.

540. Public Recreation Lands (3) Planning recreation lands; legislation, financing, intergovernmental coordination to acquire and develop open space land, urban recreation and park master plan.

550. (Ph.Ed. 550) Seminar in Health and Physical Education and Recreation (1-6)

560. Administrative Problems of Recreation and Parks (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.

590. Philosophical and Social Bases of Recreation (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

REGIONAL PLANNING

Frank B. Burggraf, Jr.
Chairman of the Committee on Regional Planning
318 Sackett Building

Degree Conferred: M.R.P.

This program emphasizes the training of technically competent planners and the development of their awareness of the importance of the social, political, economic, and cultural goals of the citizens in a region. Requirements for admission include at least one course each in sociology or political science; physical geography, geology, or soils; and engineering or architectural graphics, plus 6 credits in mathematics.

REGIONAL PLANNING (R PL)

400-401. Principles of Regional Planning (3 each)
410. Planning Programs (3)
420. Theory and Methodology of Regional Planning (3)

510. Planning Techniques and Analysis I (3) Regional socio-economic structure, problems, and factors in planning; data collection, analysis, and implications.

520. Planning Techniques and Analysis II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. Planning Techniques and Analysis III (3) Physical, aesthetic, and cultural design aspects of planning. Cultural value judgments and environmental design.

540. Problems in Regional Planning (1-9) Planned individual projects involving library, laboratory (studio) or field work.

600. Thesis.

610. Thesis.

RURAL SOCIOLOGY

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
1 Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty: Senior Members—Professors Brown and John; Associate Professor Bealer. Associate Members—Associate Professor Fliegel; Assistant Professors King and Willits.

In all programs emphasis is on a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, there are available certain areas of special interest and research: consumer behavior; instigated social change; community structure; human resource development; migration; adolescent behavior; the culture of poverty; the ecology of rurality in industrialized, urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at this University during the early part of his master's program.

RURAL SOCIOLOGY (R SOC)

401. Special Topics in Rural Sociology (1-6)
402. Consumer Behavior and the Agricultural Industry (3)
444. Rural Life in an Industrial Society (3)
452. Rural Organization (3)
459. Rural Social Psychology (3)

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology.

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems.

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452.

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior.

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system with emphasis on techniques of organization and program development.

516. Change in Rural Society (2) Social change in rural society emphasizing prediction and control of the change process.

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING

Benjamin A. Whisler
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.

Graduate Faculty: Senior Members—Professors Kountz, Nesbitt, and Whisler. Associate Member—Assistant Professor McDonnell.

The entering student should be a graduate in sanitary engineering from an accredited college of engineering, but a graduate in civil engineering may obtain the M.S. in sanitary engineering by taking a limited amount of extra undergraduate work in subjects appropriate to the sanitary engineering field. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 471, 472, 571, 572, 573, 574, 575, 576, 577, and 578. Appropriate courses offered by other departments include: Ag. 400; Bioch. 425, 436; Chem. 405; Cmp.Sc. 402; Geol. 452; Meteo. 445; Micrb. 401, 414; Nuc.E. 420; Pl.Sc. 419; and Zool. 410.

SCHOOL PSYCHOLOGY

Joseph L. French
Chairman of the Committee on School Psychology
119 Education and Psychology Center

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Carriker, French, Harris, Lathrop, Lundy, and Rabinowitz; Associate Professors Frick and Thevaos. Associate Member—Assistant Professor Cardon.

This interdisciplinary program based on courses in psychology, educational psychology, special education, and related fields is designed to produce dually oriented professionals who are well prepared in both psychology and education. The objective is to develop a psychologist who is interested in and knowledgeable about schools. The school psychologist must utilize his professional skills and his knowledge about

children and youth to make contributions which are meaningful to and utilized by teachers. The development of competencies needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Other areas of study related to school psychology, such as clinical psychology, general educational psychology, counselor education, and child development, are found in other departments of the University.

Practicum facilities include the speech pathology and audiology out-patient service, the Reading Center, the Psychology Clinic, and the Demonstration School for mentally retarded children. Facilities for work with children are available through other departments also.

An undergraduate major in psychology or in education of exceptional children is expected of applicants, but students with less than 15 credits in psychology may be admitted with limited deficiencies to be made up concurrently with their graduate studies. Requirements for admission include a minimum junior-senior scholastic average of B and a satisfactory scholastic aptitude rating. Applicants with a master's degree will be required to show more than a minimum success in graduate study, including at least one-third of their graduate credits of "A" quality.

SCHOOL PSYCHOLOGY (S PSY)

500. Professional Issues in School Psychology (1-3) Orientation to field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. Practicum in School Psychology (1-6) Clinical experience with children under supervision in a variety of settings requiring service including practice in synthesizing data and observations.

508. Internship in School Psychology (1-10) Long term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies under supervision.

SECONDARY EDUCATION

John Withall, *Head of the Department*
164 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors Fagan, Fowler, Patrick, Remaley, and Withall; Associate Professors Heimer and Pendered. Associate Members—Associate Professors Kozak, Searles, and Shemick.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the requirements, including residence, described in the earlier sections of this bulletin. For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the head of the Department of Secondary Education. When course work has been completed more than five years prior to admission to the D.Ed. or when it is transferred from another institution, the head of the department will determine its suitability for any part or all of the 15 hours required.

SECONDARY EDUCATION

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the head of the Department of Secondary Education. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or geography. These programs require 6 credits in professional education approved in advance by the head of the department responsible for the minor field chosen; e.g., secondary education, agricultural education, etc.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

SECONDARY EDUCATION (SEC ED)

400. Introduction to Research Literature (3)
426. Teaching Mathematics in the Secondary Schools (4)
433. Teaching Social Studies in the Secondary Schools (4)
436. Teaching of Conservation of Natural Resources in the Secondary School (3)
438. Teaching Science in the Secondary Schools (4)
443. Reading Problems in the Secondary School (2-3)
445. (E.E.C. 445, El.Ed. 445) Techniques in Remedial Reading (2-6)
451. Secondary Education in America (3)
453. Teaching English in the Secondary Schools (4)
454. Extracurricular Activities in the Junior and Senior High School (2-3)
472. Measurement of Achievement in the Secondary School (2-3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 406, and teaching experience.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Bot. 537, Zool. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec.Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. (El.Ed. 546) Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (3) Historical, psychological, social, and economic factors influencing secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

SLAVIC LANGUAGES AND LITERATURES

William R. Schmalstieg
Acting Head of the Department of Slavic Languages
127 Sackett Building

Degree Conferred: M.A.

Graduate Faculty: Senior Members—Professor Magner and Schmalstieg. Associate Member—Associate Professor Birkenmayer.

Opportunities for specialization in literature or linguistics are available. A minimum requirement for admission is an undergraduate major in Russian or its equivalent. The department prefers that M.A. candidates in this major submit a term paper rather than a thesis.

RUSSIAN (RUS)

426. Dostoevsky (3)
427. Tolstoy (3)
430. Methods and Materials for Teaching Russian (3)
450. History of the Russian Language (3)
460. Linguistic Analysis of Contemporary Russian (3)

*1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

*2G. Russian Texts (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

501. Readings in Russian Literature (3-6) Prerequisite: Rus. 204.

525. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

540. Seminar in Old Russian Literature (3) Literary and linguistic analysis of Russian literary monuments in the original, 1100-1800. Prerequisite: Rus. 450.

542. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

SLAVIC (SLAV)

500. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literature.

550. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

560. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

SOCIAL STUDIES

Hugo A. Meier
Chairman of the Committee on Social Studies
112 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, requires at least 24 credits chosen from economics, history, human geography, political science, and sociology. A candidate is expected to complete at least 3 credits each in four of these areas but not more than 12 in any one of them. A minor of at least 6 credits in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses in economics, history, political science, and sociology and should have had some advanced undergraduate work in at least one of these areas. He must also have had 18

* No graduate credit is given for this course.

credits in education and related psychology, and he should be certified for teaching social studies. Ideally, he should have had teaching experience in this field as well.

SOCIOLOGY

Donald P. Kent
Head of the Department of Sociology and Anthropology
236 Temporary Office Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty: Senior Members—Professors Clark, Kent, Mather, Sherif, and Theodorson; Associate Professors Aurbach and Dansereau. Associate Members—Professors Foreman and M. B. Matson; Associate Professor Raphael; Assistant Professors Faulkner, Lanphier, and Westby.

Major research and instructional areas of emphasis include sociological theory, research methods and statistics, social psychology, demography and ecology, community structure, industrial and occupational sociology, gerontology, and the sociological analysis of institutions, including political, religious, and educational sociology.

Undergraduate preparation must include 12 credits in sociology and at least 6 in other social sciences. Students of exceptional ability who are deficient in undergraduate preparation may be accepted provided they make up their course deficiency without graduate credit.

A thesis is required of all M.A. candidates in this major.

SOCIOLOGY (SOC)

400. Advanced General Sociology (3)
401. Social Institutions (3)
403. Advanced Social Psychology (3)
404. Small Groups (3)
406. Sociological Analysis of Deviance (3)
408. Social Ecology (3)
412. Penology (3)
413. Methods and Techniques of Social Research (3)
415. The Urban Community (3)
416. (C.F.Ed. 416) Sociology of Education (3)
418. The Development of Social Thought (3)
419. Negro-White Relations (3)
422. History of Sociological Theory (3)
423. Population Analysis (3)
424. Social Change (3)
426. Public Welfare Policy and Services (3)
427. Social Case Work (3)
428. Seminar in Sociology (1-6)
429. Social Stratification (3)
430. Family in Cross-Cultural Perspective (3)
432. Collective Behavior (3)
435. Social Gerontology (3)
436. (Journ. 436) Sociology of Opinion Formation (3)
444. Complex Organizations (3)

446. Political Sociology (3)
450. Community Organization (3)
453. (Anthy. 453) Primitive Religion (3)
454. Industry and the Community (3)
455. (L.M.R. 455) Occupations and Professions (3)
456. Readings in Sociology (1-9)
457. Field Work in Industrial Sociology (1-6)
461. (Rl.St. 461) Sociology of Religion (3)
470. Intermediate Social Statistics (4)
473. Methods of Demographic Analysis (3-6)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the overall structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

505. Current Social Theory (3) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

510. Field Work in Sociology (1-6)

513. Seminar in Sociological Research Problems: A. Research Techniques; B. Current Research (3-6) Prerequisite: 3 credits in statistics.

515. Seminar in Community Studies (3)

518. Research Studies in the Sociology of Education (3) Analyses of the design, methods, and findings of selected classical and current research studies in the sociology of education. Prerequisite: Soc. 416.

523. Population Problems (1-6)

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572. Methods of Sampling (3) Application of sampling techniques to sociological research.

SOLID STATE SCIENCE

L. N. Mulay
In Charge of Graduate Programs in Solid State Science
109 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Brindley, Buessem, Cross, Faust, Henisch, Muan, Roy, Vand, and Walker; Associate Professors Barsch, Inman, Kline, Mulay, Newnham, Vedam, and Weber; Assistant Professor W. White; Mrs. Roy. Associate Members—Associate Professor Kiusalaas; Assistant Professors Knox, McKinstry, and E. White.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree. The aim of this program is to provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this field must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined by the committee. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. They should be interested specifically in an interdisciplinary program of study and research. Dissertation research on various aspects of the solid state may be conducted in the Materials Science Department and other appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science; in the Materials Research Laboratory; and in the Ordnance Research Laboratory. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

In addition to the departmental courses, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy the requirements; descriptions may be found under the appropriate department headings. Structure of Solids: Chem. 516; Gchem. 512; Min. 463, 500; Mn.Sc. 421, 510, 513. Solid State Theory: Chem. 544, 545, 565, 566, 567; E.Mch. 507, 516, 531, 540; Metal. 514; Phys. 410, 412, 470, 512-513, 517, 561-562, 571. Physical Properties of Solids: Cer.Sc. 506, 507, 508; Chem. 455; E.Mch. 414, 506, 530, 533, 546; Metal. 516; Nuc.E. 509. Chemical Reactions in Solids: Cer.Sc. 503, 504, 511, 512; Chem. 563; F.Sc. 506, 515; Gchem. 513, 520; Metal. 508, 515, 518, 522.

SPANISH

Anthony M. Pasquariello
Head of the Department of Spanish, Italian, and Portuguese
212 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members—Professors Moser, Pasquariello, Pérez, and Sturcken; Associate Professor Brentin. Associate Members—Associate Professor Dalbor; Assistant Professors Halsey, Solera, and Triolo.

The minimum requirement for admision will normally be 24 credits of post-intermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

SPANISH (SPAN)

400. Advanced Composition and Conversation (3)
404. The Evolution of Spanish (3)
413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)
*450. Spanish Institute (7-14)
452. Spanish Literature in the Romantic Period (3)
459. The Generation of 1898 (3)
472. The Contemporary Spanish-American Novel (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
480. Literature of the Gaucho (3)
482. Spanish Lyric Poetry (3)
483. Spanish Drama of the 19th Century (3)
487. The Spanish Novel of the 19th Century (3)
498. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation.

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials.

505. Old Spanish: Phonology, Morphology, and Syntax (3)

506. History of the Spanish Language (3)

507. Hispano-Romance Linguistics (3)

510. Spanish Descriptive Linguistics: Phonology (3)

* A maximum of 7 credits in one summer.

511. Spanish Descriptive Linguistics: Morphology and Syntax (3)

514. Hispanic Dialectology (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish.

515. Medieval Spanish Literature (3)

518. El Libro De Buen Amor (3)

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry.

528. Spanish Renaissance and Golden Age Prose (3) Various types of novels with special emphasis on the picaresque; didactic literature; histories.

535. Seminar in Renaissance and Golden Age Literature (3-6) Nature and development of Spanish literature of the 16th and 17th centuries; topics will vary.

537. Lope de Vega and Calderón (3) Major works of these and other dramatists of the Golden Age.

540. Cervantes and His Works (3)

543. Spanish Literature of the 18th Century (3) Didactic literature, poetry, drama, and novel in the most representative writers in the century.

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós.

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others.

563. Contemporary Drama in Spain (3) The drama since 1898, to the present day: Benavente, Valle Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others.

564. Twentieth Century Hispanic Literature (3-6) Principal trends and works after the Generation of 1898 and *modernismo;* topics will vary.

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío.

573. Survey of the Spanish American Novel (3) Trends in the Spanish American novel, such as *romanticismo, criollismo.*

575. The Spanish American Essay (3) Tracing the history of ideas in Spanish America through major essayists.

576. Spanish American Lyric Poetry (3) Aspects of Spanish American lyric poetry, with emphasis on the 20th century after *modernismo.*

577. Spanish American Drama (3) Dramatic literature in Spanish America from colonial times to the present.

578. Indianismo (3) The Indian as a theme in Spanish American poetry and prose.

580. History of the Spanish Essay (3) The principal essayists from the 16th century to the present.

581. The Spanish-American Short Story (3) Critical analysis of the major writers and movements from Echeverría to the present.

585. Hispanic Poetry of the 19th and 20th Centuries (3) Various currents in the poetry of the Iberian peninsula and Latin America.

586. Evolution of the Picaresque Hero in Spanish Literature (3) An analysis of the changing character and his environment since Lazarillo to the present day.

598. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature.

SPEECH

Stanley F. Paulson, *Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty: Senior Members—Professors Arnold, Brubaker, Holtzman, Nelson, Oliver, Paulson, Schug, White, and Zelko; Associate Professors Fife and Phillips. Associate Members—Associate Professors Dunham, Hungerford, and Olbricht; Assistant Professors Borden, Gregg, and Grove.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

A thesis is required of all M.A. candidates in this major.

SPEECH (SPCH)

400. Teaching of Speech (3) *Mr. Schug*
402. General Semantics (3) *Mr. Phillips*
410. English Phonetics and Pronunciation (3) *Mr. Brubaker*
412. Speech Criticism (3) *Mr. Arnold*
417. Directing Forensics (3) *Mr. Dunham*
425. Radio Programming and Performance (3) *Mr. Nelson*
431. Anatomy and Physiology of the Ear and Vocal Mechanisms (3) *Mr. Brubaker*
435. Radio and Television Programming (3) *Mr. Nelson*
437. Television Programming and Performance (3) *Mr. Hungerford*
450. Discussion: Research and Theory (2-6) *Mr. Phillips*
460. Oriental Rhetoric (3) *Mr. Oliver*
461. Contemporary Public Address in the Far East (3) *Mr. Oliver*
475. Studies in Mass Persuasion in the Democratic Society (3) *Mr. Hager*
477. Contemporary Public Address: the Great Dictators (2) *Mr. Oliver*
478. Contemporary Public Address: English and American Speakers (2) *Mr. Gregg*
485. Advanced Oral Interpretation of Literature (3) *Mr. Hamilton*
490. Psychology of Speaking and Listening (3) *Mr. Holtzman*
494. Teaching of English as a Second Language (3) *Mr. Holtzman*
496. Speech for Teachers (3) *Mr. Brubaker*

500. Seminar in American Oratory (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. Research Methods in Speech (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Preston*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech. *Mr. Gregg*

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Phillips*

520. Seminar in Speech Science (2-4) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Mr. Brubaker*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Mr. Paulson*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Mr. Zelko*

555. Speech Communication: Problems and Principles (2-6) Prevalent theories of speech influence. *Messrs. Borden, Oliver, and Phillips*

564. Seminar in European Oratory (2-4) Analysis of significant European speeches with consideration of cultural influences on invention and style. Prerequisite: 6 credits in speech. *Mr. Olbricht*

575. Research Problems in Speech (1-9) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology.

SPEECH PATHOLOGY AND AUDIOLOGY

Bruce M. Siegenthaler
In Charge of Graduate Programs in Speech Pathology and Audiology
2S Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Members—Professors McDonald and Siegenthaler. Associate Members—Associate Professors Berlin and Frick; Assistant Professor Haspiel.

Students may specialize in either speech pathology or audiology. Admission to study for the master's degree requires 27 credits in clinical speech and hearing, education, and psychology, including at least 9 in speech pathology and/or audiology and a course in statistics. The major is one of the areas of study within the Department of Special Education.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. (E.E.C. 440) Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

532. Acoustical Instruments for Hearing (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. (E.E.C. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. (E.E.C. 546) Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

STATISTICS

James B. Bartoo, *Head of the Department of Mathematics*
228 McAllister Building

Degrees Conferred: Ph.D., M.A., M.S.

Graduate Faculty: Senior Members—Professors Bennett, Griffiths, Patil, and Schipper; Associate Professors Harkness and Starling. Associate Members—Professor Bartoo; Associate Professor Hultquist; Assistant Professor Borden.

The modern science of mathematics and applied statistics is concerned with the general principles of dealing wisely with uncertainty and partial ignorance through mathematical probability.

To be admitted as a candidate for an M.A. or M.S. degree, the individual must possess an undergraduate degree with a background in mathematics including at least one and one-half years of calculus. Additional mathematical and statistical training is desirable. Admission to candidacy for the Ph.D. degree is granted only upon the recommendation of the faculty in statistics.

A Master of Arts, emphasizing mathematical statistics, requires a minimum of 24 credits of course work and a thesis (6 credits) or a minimum of 30 credits of course work and a term paper. A Master of Science, emphasizing applied statistics, requires a minimum of 24 course credits and a thesis (6 credits).

STATISTICS

In addition to meeting the Graduate School requirements for the doctorate, a candidate for a Ph.D. in statistics must pass written qualifying examinations in three fields. These are ordinarily probability theory, mathematical statistics, and mathematical analysis. Candidates must also complete at least 4 credits in algebra and 4 credits in topology, with at least 2 credits in each at the 500 level. Programs and qualifying examinations for a student specializing in another area of statistics must be approved by the faculty in general and specifically by the candidate's committee.

STATISTICS (STAT)

400. Intermediate Statistical Analysis (3)
409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)
411. Practicum (1)
418. (Math. 418) Introduction to Probability Theory (3)

501. Theory of Statistics (3) Sufficiency and completeness, testing hypotheses, sequential analysis, chi-square tests, analysis of variance. Prerequisite: Stat. 410.

502-503. Analysis of Variance and Regression (3 each) Linear hypotheses, regression, analysis of variance and covariance, mixed and random effects models, multiple comparisons, designs. Prerequisites: Stat. 410; Math. 441 or 481.

504. Nonparametric Statistics (3) Goodness-of-fit tests, contingency tables, analysis of multinomial and percentage data, multi-sample problems, special topics. Prerequisite: Stat. 410.

505. Multivariate Statistical Analysis (3) Statistical procedures associated with the multivariate normal distribution. Prerequisites: Stat. 410; Math. 441 or 481.

506. Sampling Theory (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

516. (Math. 516) Intermediate Probability Theory (3) Random walk and recurrent events, Markov chains, and the simplest time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) Advanced Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 501, Stat. 541.

541. (Math. 541) Mathematical Statistical Analysis (3) Probability spaces, random variables, distribution and characteristic functions, convergence theorems, univariate and multivariate distribution theory. Prerequisite: Math. 421.

542-543. (Math. 542-543) Advanced Theory of Statistics (3 each) Exact and asymptotic sampling distribution theory, rigorous treatment of sufficiency, completeness, estimation, and testing. Prerequisites: Stat. 410, 541.

577. (Math. 577) Special Topics in Probability and Statistics (3-12)

590. Seminar in Statistical Methods (1-6) Lectures on current statistical methods; presentation and discussion of literature treating various special topics in statistics.

THEATRE ARTS

WILLIAM H. ALLISON, *Head of the Department*
103 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty: Senior Members—Professors Neusbaum, Smith, and Walters; Associate Professors Reifsneider and Yeaton; Assistant Professor Manfull. Associate Member—Associate Professor Allison.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.

The M.F.A. program is planned to provide a professional emphasis. Students will take a core program and specialize in performance (acting, directing), dramatic writing, or production (scene design, technical direction, stage lighting, stage costuming).

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

Requirements for admission to the M.A. program are a broad undergraduate preparation; one course each in basic acting, directing, theatre crafts, and history of the theatre, or their equivalents; and 12 credits divided among speech, music, art, and dramatic literature, or 9 credits in one of these fields.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, 3 of which must be in history of the theatre. In certain cases courses in speech, dramatic literature, art, music, dance, architecture, and other similar subjects may be accepted.
2. Auditions or submission of manuscripts, portfolios, photographs of theatre work, or other evidence of ability, according to specialization, as arranged by the student with the department.

All students in the M.A. and M.F.A. programs who lack the expected upper-class undergraduate courses in theatre may be requested to take additional course work without degree credit. All graduate majors are required to participate in University Theatre productions in positions of responsibility.

THEATRE ARTS (THEA)

404. STYLES OF ACTING (3-6)
412. ADVANCED SCENE DESIGN (3-6)
413. STAGE LIGHTING (3)
414. STAGE COSTUMING (3)
415. THEATRE ORGANIZATION AND MANAGEMENT (3)
421. ADVANCED PLAYWRITING (3)
430. ANCIENT AND MEDIEVAL THEATRE (3)
431. THEATRES OF THE RENAISSANCE AND THE ORIENT (3)
432. HISTORY OF THE MODERN THEATRE (3)
433. DANCE FOR THE THEATRE (3)
442. CREATIVE DRAMATICS WITH CHILDREN (3)
443. MARIONETTES AND PUPPETRY (3)
451. DIRECTING (3-6)
452. CENTRAL STAGING (3)
470. THEATRE PRODUCTION (1-6)
471. THE EUROPEAN FILM (3)
472. THE AMERICAN FILM (3)
473. MOTION PICTURE TECHNIQUES (3-6)

481. Television Drama (3)
482. Radio and Television Directing (3)

501. Directing (1-6 per term)

502. Technical Theory in Dramatic Production (3-6)

504. Styles of Acting (3-12)

506. The Contemporary Theatre (3-6)

507. Dramatic Theory (3-6)

512. Stage Design (1-6 per term)

521. Playwriting (3-12) Prerequisite: Thea. 421.

VOCATIONAL INDUSTRIAL EDUCATION

George L. Brandon
Head of the Department of Vocational Education
250 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty: Senior Member—Professor Brandon. Associate Members—Professor Williams; Associate Professor Brantner; Assistant Professors Bjorkquist and Impellitteri.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial education is required for admission.

INDUSTRIAL EDUCATION (I ED)

402v. Supervision of Vocational Education (3)
403v. Supervised Field Work (6)
408v. Occupations (3)
409v. Tests and Measurements (3)
412v. Special Problems in Vocational Education (4)
415v. Problems in Coordinating Vocational Education (3)
420v. Occupational Hygiene (3)
427v. Advanced Course of Study Building (3)
446v. Improvement of Instruction in Vocational Education (4)
450v. Shop Layout and Management (3)

501v. Seminar in Vocational Education (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. Administration of Vocational Education (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. Vocational Education for Administrators (3) Designed for school ad-

ministrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. Research in Vocational Education (3) Research techniques in vocational industrial education.

556v. Federal Legislation (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. Present-Day Local, Personnel, and Curriculum Problems (2-3) Various plans, techniques, and practices.

558v. State and Local Supervision and Administration (2-3) The more important recent problems in organization, supervision, and administration.

559v. Vocational Technical Education (2-3) Problems of organization and administration of programs of technical education at the secondary and post-secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT

Wilber W. Ward, *Director of the School of Forest Resources*
101 Forestry Building

or

Tien-Hsi Cheng, *Professor of Zoology*
208 Life Sciences Building

Degree Conferred: M.S.

Graduate programs in the field of wildlife management are offered by the Department of Forestry and Wildlife for students primarily interested in the habitat aspects, and by the Department of Biology for those primarily interested in the animal aspects.

ZOOLOGY

Tien-Hsi Cheng, *In Charge of Graduate Programs in Zoology*
208 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty: Senior Members—Professors Anderson, Anthony, Boyle, Cheng, Cooper, Dalton, Hale, Schein, and Wright; Associate Professors Bellis, Grun, Houlihan, and Lytle; Assistant Professors Hymer and Pubols. Associate Members—Associate Professors Butler and Wood; Assistant Professors Dunson, Taub, and Wickersham.

Programs are offered in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, population dynamics, or wildlife management. The

bachelor's program must show emphasis on zoological subjects and include adequate preparation in mathematics and physical sciences. Each applicant must provide Graduate Record Examination scores, letters from two persons most familiar with his academic qualifications, and a personal statement of his primary interests and objectives. A limited deficiency may be made up without degree credit while pursuing graduate work.

ZOOLOGY (ZOOL)

401. (Pty.Sc. 401, Psy. 401) Animal Behavior (3) *Mr. Hale*
403. (Ent. 403) Systematics (3) *Mr. Boyle*
405. (Bot. 405) General Cytology (3) *Mr. Grun*
408. Mammalogy (4) *Mr. Davis*
410. General Limnology (3) *Mr. Cooper*
415. The Literature of Zoology (1) *Mr. Anderson*
416. The Methods of Research in Zoology (2) *Mr. Anderson*
417. Invertebrate Zoology (3) *Mr. Lytle*
419. General Animal Ecology (3) *Mr. Bellis*
421. Comparative Anatomy of Vertebrates (4) *Mr. Taub*
422. (Bot. 422) Advanced Genetics (3) *Mr. Wright*
437. Histology (4) *Mr. Anthony*
440. Embryology (4) *Mr. Taub*
444. Zoological Problems (1-6)
448. Ornithology (3) *Mr. Wood*
450. Ichthyology (3) *Mr. Cooper*
461. Animal Parasitology (3)
471. Vertebrate Physiology (3) *Mr. Houlihan*
475. Cell Physiology (3) *Mr. Hymer*
479. General Endocrinology (3) *Mr. Wickersham*

505. (Bot. 505) Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Zool. 405 or 422. Spring term, odd years. *Mr. Grun*

509. Techniques in Wildlife Management (2) Evaluation of procedures designed to manage populations of game and fish; elements of statistics of birth and mortality rates; census methods. Fall term. *Mr. Davis*

512. Seminar (1) Review of current zoological literature. Required of graduate students majoring in zoology and entomology.

520. Special Topics (1-6)

524. (Bot. 524) Seminar in Genetics (1 per term) *Mr. Wright*

533. (Bot. 533) Problems in Genetics (2-6) Problems to suit needs of individual students; conferences and laboratory work. *Messrs. Wright and Grun*

537. (Bot. 537, Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools. Summer term.

541. Comparative Physiology (3) Phylogenetic variation in the regulation of the internal environment of animals. *Mr. Dunson*

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term. *Mr. Davis*

551. Fisheries Management (3) Basic principles underlying management of inland waters for fish production. Summer term, even years. *Mr. Cooper*

571. (Phsio. 571) Animal Physiology (2) Physiology of fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood, and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Phsio. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Phsio. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates and special senses. Prerequisite: 3 credits in physiology.

574. (Phsio. 574) Animal Physiology Laboratory (3) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisites: Phsio. 571, 572. Prerequisite or concurrent: Phsio. 573.

575. Advanced Cell Physiology (3) Current topics and experiments in cell physiology. *Mr. Hymer*

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals. *Mr. Lytle*

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Davis, Hale, and Schein*

583. Experimental Endocrinology (4) Problems in endocrinology designed to demonstrate the role of hormones in the regulation of physiological phenomena. *Mr. Wickersham*

OTHER ELECTIVE GRADUATE COURSES

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

AMERICAN STUDIES (AM ST)

402. Seminar in American Studies (3-9)

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3) *Mr. Hicks*

APPLIED MATHEMATICS (A M)

405. (Math. 405) Fourier Series and Partial Differential Equations (3)
417. (Math. 417) Tensor Analysis (3)
419. (Phys. 419) Theoretical Mechanics (3)
431. (Math. 431) Ordinary Differential Equations (3)
441. (Math. 441) Matrix Algebra (3)
451. Functions of Several Variables (3)
452. (Math. 452) Functions of a Complex Variable (3)
461. (Phys. 461) Theoretical Mechanics (3)
490. Special Topics (1-12)

510-511. Linear Methods (3 each) Matrices, quadratic forms, ordinary and partial differential equations, integral equations, transforms, Fourier series. Prerequisite or concurrent: A.M. 452.

520. Asymptotic Techniques in Differential Equations (3) Asymptotic series; applications to ordinary and singular perturbation problems. Prerequisite: A.M. 511.

540. Magnetohydrodynamics (3) The mathematical description of the interaction of an electrically conducting fluid with electromagnetic fields. Prerequisites: A.M. 511, Phys. 557.

550. (Phys. 550) Applied Group Theory (3) Representations of discreet and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

555. Introduction to Group Representations (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions, with orientation to chemistry and physics.

590. Special Topics (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. Contemporary Forms in Art, Music, Theatre (3)

BIOLOGY (BIOL)

501. Evolution (2) Selected Topics on the Evolution of Life.

538. Principles of Microscopic Histochemistry (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Zool. 437 or 405.

539. Analytical Histochemistry Laboratory (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids, and proteins. Prerequisite or concurrent: Biol. 538.

*CLASSICS (CLASS)

401. The Classics and Archaeology (3)
405. Greek and Roman Mythology (3)
408. Greek Religion and Modern Man (3)
410. Classical Epic (3)
411. Classical Drama (3)
412. Classical Historians (3)
413. Readings in Classical Literature (3)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

416. (Soc. 416) Sociology of Education (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
419. History of Education in Ancient and Medieval Times (3)
420. History of Modern European Education (3)
422. Introduction to Comparative Education (3)

515. Experimentalist Philosophies of Education (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. Topical Seminar on School and Society (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

519. Contemporary Philosophies of Education (2-3) Implications for education of various types of Realism, Idealism, Existentialism, and Analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

520. Comparative Philosophies of Education (2-3) Effect of ideologies on education in selected national systems; emphasis on relationships between theory and educational practice. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. Comparative European Education (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. Education in Communist Countries (2-3) Educational policies and prac-

*Knowledge of Latin or Greek is not required of students in these courses.

tices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. Education in Developing Countries (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

528. Education in Canada (2-3) Development and organization of education in the Canadian provinces; emphasis on dual systems of Ontario and Quebec. Prerequisite: C.F.Ed. 422.

532. Social Change, Cultural Dynamics, and Education (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. Readings in Philosophy of Education (1-6) Selected philosophic writings—classic, modern, or contemporary—on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. Educational Leaders and Classics (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Feelon, Pestalozzi, and Mann.

591. Seminar in Cultural Foundations of Education (1-9) Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

ENGINEERING (ENGR)

450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

531. Advanced Digital Computer Programming (3) Nonnumerical applications; symbol manipulation, syntactical analysis, and translation of artificial languages; heuristic methods, learning mechanisms, artificial intelligence.

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

FOOD TECHNOLOGY (FD T)

400. Effects of Processing on Food (3)
401. Sanitation and Quality Control (3)
402. The Thermal Process (1)
421. Technical Control Problems (1-10)

GREEK (GREEK)

420. The Greek Historians (3)
421. Greek Tragedy (3)
422. Greek Comedy (3)
425. Homer (3)
430. The Greek Philosophers (3-9)
450. Topics in Greek Literature (3-6)
451. History of the Greek Language (3)

507. Problems in Greek Archaeology (3-9)

509. Greek Seminar (3-9)

517. Greek Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

INSTRUCTIONAL MEDIA (INST M)

435. Orientation to Instructional Media (2)
436. Production and Utilization of Graphic Stimulus Materials (3)
437. Production of Educational Motion Pictures (3)
443. Television in Education (3)

531. Organization and Administration of Media in Schools (2) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 435.

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

598. Seminar in Italian Literature (3-12) Common and individual research in special problems.

LABOR-MANAGEMENT RELATIONS (L M R)

411. Trade Union Administration (3)
421. Labor Education (3)
455. (Soc. 455) Occupations and Professions (3)
475. (Econ. 475) Theories of the Labor Movement (3)

LANDSCAPE ARCHITECTURE (L ARCH)

420. Landscape Ecology (3)
425-426. Landscape Construction Problems (3 each)
427. Landscape Construction Problems (2)
434. Urban Park and Recreation Areas (3)
454-455. Landscape Design (3 each)
460-461-462. Advanced Landscape Design (4-8 each)
471. Park Systems (2)
472. Planning and Public Policy (3)
473. Recreation Resource Planning (3)
474. Site Engineering Fundamentals (1)

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LATIN (LATIN)

420. The Latin Historians (3)
428. Lucretius (3)
429. Quintilian (3)
430. Medieval Latin (3-6)
431. Juvenal (3)
436. The Teaching of Latin (3)
437. Latin Prose Composition (3-6)
460. Topics in Latin Literature (3-6)
461. History of the Latin Language (3)

500. Latin Literature (3-9) Readings in the major forms of Latin literature; content varies and the course may be repeated.

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. Prerequisites: two 400-level courses in Latin.

510. Latin Seminar (3-9)

518. Latin Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LIBERAL ARTS (L A)

498. Undergraduate Seminar: Selected Topics (3-9)

LINGUISTICS (LING)

400. Introduction to Transformation Grammar (3)
402. Historical Linguistics (3)

500. Generative Linguistics (3) Types of grammatical rule and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

501. Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

503. Generative Syntax (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.

504. Generative Phonology (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.

505. Seminar in Historical Linguistics (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: 1 graduate course in linguistics.

MINERAL SCIENCES (MN SC)

411. Instrument Techniques Applied to Mineral Science Problems (1-3)
421. X-ray Diffraction (3)
431. Instrumentation for Physical Measurement and Control (3)

510. X-ray and Electron Diffraction Analysis as Applied to Minerals and Metals (2-4) Prerequisite: Mn.Sc. 421.

513. Semiconductor Physics (3) Electronic structure of solids; electronic transport phenomena; semiconductor materials; luminescence. Prerequisite: Phys. 400 or E.E. 32. *Mr. Henisch*

PORTUGUESE (PORT)

598. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems.

RELIGIOUS STUDIES (RL ST)

402. Contemporary Religious Thought (3)
409. Buddhism (3)
430. Religion and Morality (3)
440. Problems in Religious Studies (3-6)
461. (Soc. 461) Sociology of Religion (3)

502. Studies in Comparative Religions (3-6) Cross-cultural comparative studies of two or more major world religions.

505. Seminar in Asian Religions (3-6) Studies in selected Asian religions.

520. Early and Medieval Western Religion (3-6) Studies in Judaism and Christianity from the 1st century A.D. to 1500.

530. Religion and Society (3-9) Studies of mutual influences and effects of religious and secular phenomena.

VETERINARY SCIENCE (V SC)

400. Veterinary Anatomy and Physiology (3)
401. Infectious Diseases of Domestic Animals (3)
420. General Animal Pathology (3)

515. (Micrb. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

520. Histopathology (3) Specific microscopic alterations and reactions developing in the living animal body when exposed to injurious agents or deprivations.

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University Bulletin

Graduate Degree Programs

1969-1970

THE PENNSYLVANIA STATE UNIVERSITY

GRADUATE DEGREE PROGRAMS

GENERAL CATALOG ISSUE

FEBRUARY 1969

OFFICES OF THE GRADUATE SCHOOL

M. Nelson McGeary, *Dean*

University Park Campus
101 Willard Building
University Park, Pa. 16802
Telephone: Area Code 814, 865-6323

Helmut E. Weber, *Assistant Dean*

King of Prussia Graduate Center
Gulph and Henderson Roads
King of Prussia, Pa. 19406
Telephone: Area Code 215, 265-5400

Richard H. Heindel, *Dean of the Faculty*

Capitol Campus Graduate Center
P. O. Box 230
Middletown, Pa. 17057
Telephone: Area Code 717, 944-5571

David P. Spalding, *Assistant Dean*

Behrend Graduate Center
Station Road
Erie, Pa. 16510
Telephone: Area Code 814, 899-3101

George T. Harrell, Jr., *Dean and Director*

The Milton S. Hershey Medical Center
The Pennsylvania State University
500 University Drive
Hershey, Pa. 17033
Telephone: Area Code 717, 534-8521

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* GRADUATE CALENDAR

WINTER TERM 1969

NOVEMBER 1968

4 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1969

DECEMBER

3 Tuesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1969

JANUARY 1969

3-4 Friday and Saturday—Winter Term Registration
3-4 Friday to Saturday Noon—Pre-examinations in German for Advanced Degree Candidates
6 Monday—Winter Term Classes Begin 8 a.m.
10 Friday—Last Date for Registering with Foreign Language Departments (Other than French) for Written Language Examinations
21 Tuesday—Graduate Faculty Meeting
22 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
25 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee
27 Monday—Last Date for Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates

FEBRUARY

1 Saturday—Last Date for Final Oral Doctoral Examination for March Graduates
1 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser
7 Friday—Last Date for Registering with French Department for Written Language Examination
15 Saturday—Written French Language Examination for Advanced Degree Candidates
17 Monday—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

MARCH

1 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally
8 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in March
15 Saturday—Winter Term Classes End 12:25 p.m.
17-19 Monday to Wednesday—Final Examinations
22 Saturday—Commencement

SPRING TERM 1969

JANUARY 1969

27 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1969

* This calendar was approved by the Board of Trustees and is subject to change without notice. In preparing the calendar for an academic year, the University makes every effort to avoid conflicts with religious holidays. However, such conflicts are sometimes unavoidable. When they occur, efforts are made to make special arrangements for the students affected.

FEBRUARY

26 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1969

MARCH

26-28 Wednesday to Friday—Spring Term Registration
26-28 Wednesday to Friday—Pre-examinations in German for Advanced Degree Candidates
31 Monday—Spring Term Classes Begin 8 a.m.

APRIL

4 Friday—Last Date for Registering with Foreign Language Departments (Including French) for Written Language Examinations
12 Saturday—Written French Language Examination for Advanced Degree Candidates
15 Tuesday—Graduate Faculty Meeting
16 Wednesday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
19 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
21 Monday—Last Date for Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates
26 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
26 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

MAY

12 Monday—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
24 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally
31 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in June

JUNE

7 Saturday—Spring Term Classes End 12:25 p.m.
9-11 Monday to Wednesday—Final Examinations
14 Saturday—Commencement

SUMMER TERM 1969

APRIL 1969

24 Thursday—Last Date for a Prospective Graduate Student to Apply for Admission to the Summer Term 1969

MAY

24 Saturday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Summer Term 1969

JUNE

24-25 Tuesday and Wednesday—Summer Term Registration
24-25 Tuesday and Wednesday—Pre-examinations in German for Advanced Degree Candidates
26 Thursday—Summer Term Classes Begin 8 a.m.

JULY

3 Thursday—Last Date for Registering with Foreign Language Departments (Other than French) for Written Language Examinations
4 Friday—Independence Day Holiday
14 Monday—Last Date for a September Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
15 Tuesday—Graduate Faculty Meeting
19 Saturday—Last Date for a September Graduate to Deliver Doctoral Thesis to Committee
21 Monday—Last Date for Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates
25 Friday—Last Date for Registering with French Department for Written Language Examination
26 Saturday—Last Date for Final Oral Doctoral Examination for September Graduates
26 Saturday—Last Date for a September Graduate to Deliver Master's Thesis or Paper to Adviser

AUGUST

2 Saturday—Written French Language Examination for Advanced Degree Candidates
11 Monday—Last Date for a September Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
23 Saturday—Last Date for a September Graduate to Rent Cap, Gown, and Hood Locally
30 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in September

SEPTEMBER

5 Friday—Summer Term Classes End 9:55 p.m.
8-9 Monday and Tuesday—Final Examinations
13 Saturday—Commencement

FALL TERM 1969

JULY 1969

25 Friday—Last Date for a Prospective Graduate Student to Apply for Admission to the Fall Term 1969

AUGUST

25 Monday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Fall Term 1969

SEPTEMBER

24-26 Wednesday to Friday—Fall Term Registration
24-26 Wednesday to Friday—Pre-examinations in German for Advanced Degree Candidates
29 Monday—Fall Term Classes Begin 8 a.m.

OCTOBER

3 Friday—Last Date for Registering with Foreign Language Departments (Other than French) for Written Language Examinations
15 Wednesday—Last Date for a December Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
18 Saturday—Last Date for a December Graduate to Deliver Doctoral Thesis to Committee

20 Monday—Last Date for Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates
21 Tuesday—Graduate Faculty Meeting
24 Friday—Last Date for Registering with French Department for Written Language Examination to be given on November 1
25 Saturday—Last Date for Final Oral Doctoral Examination for December Graduates
25 Saturday—Last Date for a December Graduate to Deliver Master's Thesis or Paper to Adviser

NOVEMBER

1 Saturday—Written French Language Examination for Advanced Degree Candidates
10 Monday—Last Date for a December Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
22 Saturday—Last Date for a December Graduate to Rent Cap, Gown, and Hood Locally
27 Thursday—Thanksgiving Day Holiday
28 Friday—Last Date for Registering with French Department for Written Language Examination to be given on December 6
29 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in December

DECEMBER

6 Saturday—Written French Language Examination for Advanced Degree Candidates
8 Monday—Fall Term Classes End 9:55 p.m.
9-12 Tuesday to Friday—Final Examinations
14 Sunday—Commencement

WINTER TERM 1970

NOVEMBER 1969

3 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Winter Term 1970

DECEMBER

3 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Winter Term 1970

JANUARY 1970

2 Friday—Winter Term Registration
2 Friday—Pre-examinations in German for Advanced Degree Candidates
5 Monday—Winter Term Classes Begin 8 a.m.
9 Friday—Last Date for Registering with Foreign Language Departments (Other than French) for Written Language Examinations
20 Tuesday—Graduate Faculty Meeting
21 Wednesday—Last Date for a March Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
23 Friday—Last Date for Registering with French Department for Written Language Examination
24 Saturday—Last Date for a March Graduate to Deliver Doctoral Thesis to Committee
26 Monday—Last Date for Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates
31 Saturday—Written French Language Examination for Advanced Degree Candidates

31 Saturday—Last Date for Final Oral Doctoral Examinations for March Graduates
31 Saturday—Last Date for a March Graduate to Deliver Master's Thesis or Paper to Adviser

FEBRUARY

16 Monday—Last Date for a March Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers
28 Saturday—Last Date for a March Graduate to Rent Cap, Gown, and Hood Locally

MARCH

7 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in March
14 Saturday—Winter Term Classes End 9:55 p.m.
16-19 Monday to Thursday—Final Examinations
21 Saturday—Commencement

SPRING TERM 1970

JANUARY 1970

26 Monday—Last Date for a Prospective Graduate Student to Apply for Admission to the Spring Term 1970

FEBRUARY

25 Wednesday—Last Date for a Graduate Student to Apply for Permission to Resume Study in the Spring Term 1970

MARCH

27 Friday—Spring Term Registration
27 Friday—Pre-examinations in German for Advanced Degree Candidates
30 Monday—Spring Term Classes Begin 8 a.m.

APRIL

3 Friday—Last Date for Registering with Foreign Language Departments (Other than French) for Written Language Examinations
15 Wednesday—Last Date for a June Graduate to Pay Thesis Fees and to Activate Diploma Card in Registrar's Office
18 Saturday—Last Date for a June Graduate to Deliver Doctoral Thesis to Committee
20 Monday—Last Date for Written Foreign Language Examinations (Other than French) for Advanced Degree Candidates
21 Tuesday—Graduate Faculty Meeting
24 Friday—Last Date for Registering with French Department for Written Language Examination
25 Saturday—Last Date for Final Oral Doctoral Examination for June Graduates
25 Saturday—Last Date for a June Graduate to Deliver Master's Thesis or Paper to Adviser

MAY

2 Saturday—Written French Language Examination for Advanced Degree Candidates
11 Monday—Last Date for a June Graduate to Deliver Thesis to Graduate School Office and for Departments to Certify Completion of Required Papers

23 Saturday—Last Date for a June Graduate to Rent Cap, Gown, and Hood Locally
30 Saturday a.m.—Last Date for Submitting a Petition to Graduate in Absentia in June

JUNE

6 Saturday—Spring Term Classes End 12:25 p.m.
8-11 Monday to Thursday—Final Examinations
13 Saturday—Commencement

ADMINISTRATION 1968-1969

THE UNIVERSITY

Eric A. Walker, Sc.D., LL.D., L.H.D., Litt.D., P.E.	*President*

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John Walmer, M.D. (Temple)	*Associate Professor of Education*
Walter F. Westerfeld, M.S. (Penn State)	*Professor of Botany*
Wanda Whalen, M.F.A. (Wisconsin)	*Instructor in Theatre Arts*
Joseph A. Wigley, Ph.D. (Northwestern)	*Associate Professor of Speech*

GENERAL INFORMATION

GRADUATE WORK at The Pennsylvania State University began in 1862 with two graduate students in residence. Two years later a "course for Graduates," which led to the degree of Master of Scientific Agriculture, was formally established, but for a number of years growth was slow and graduate instruction relatively unorganized. Eventually a committee of the University Senate was given the responsibility of guiding graduate study. Standards were established, and regulations were set up to govern the conferring of master's degrees and certain technical degrees. In 1922 the Graduate School was organized, and in 1924 the Board of Trustees authorized the granting of the degree of Doctor of Philosophy.

Today graduate study is offered in 112 major fields, with thirteen advanced academic and professional degrees being conferred. During the academic year 1967-68, 4,000 to 4,500 graduate students were enrolled each term, and 1,316 advanced degrees were conferred, of which 279 were doctorates. The faculty of the Graduate School, numbering about 1,100, controls all academic matters pertaining to the School, subject to review by the University Senate.

GRADUATE CENTERS—University Graduate Centers have been established in the Erie, Philadelphia, and Harrisburg areas. They operate under the immediate direction of a resident representative of the Graduate School and have full-time resident faculty members as well as part-time staff. Programs to be offered in a Center will depend upon its location, the degree of interest, and the availability of qualified students in the immediate area.

The King of Prussia Graduate Center near Philadelphia, which opened in 1963, currently has an enrollment of more than 450 students. Its program leads to the degree of Master of Engineering with a major in engineering science.

The Graduate Center at Capitol Campus opened in 1965 as the Susquehanna Valley Graduate Center. Its present enrollment is approximately 110. Programs leading to the degrees of Master of Engineering, Master of Education, and Master of Administration are currently offered; others are in the planning stage.

The Behrend Graduate Center at Erie will open with the winter term, January 1969. It has been established to offer individual courses and a program leading to the degree of Master of Engineering with a major in engineering science.

Interested students are urged to write directly to the dean at the Center for information on programs and courses. Addresses are given on the inside front cover of this bulletin.

NEW MEDICAL CENTER—A gift of $50,000,000 from the Milton S. Hershey Foundation has made possible the establishment of a medical center near Harrisburg, Pennsylvania, for which facilities are now under construction. The first class of medical students entered in the fall of 1967. The Ph.D. program will emphasize medical research and operate in close cooperation with related departments on the University Park Campus.

COOPERATIVE ARRANGEMENTS WITH OTHER INSTITUTIONS—A working arrangement has been established with Jefferson Medical College of Philadelphia whereby a candidate for an advanced degree at Jefferson may do part of his graduate work at Penn State by scheduling relevant courses and research at University Park. Similarly, a graduate student with an appropriate major at Penn State may earn credits at Jefferson which, upon advance approval by his major department, will be accepted in partial fulfillment of degree requirements at Penn State.

PROCEDURES AND REGULATIONS

A student is expected to assume full responsibility for knowing the regulations and pertinent procedures of the Graduate School as set forth in this publication, the *Manual for Graduate Students,* and the *Thesis Information Bulletin,* and for meeting the standards and requirements expressed by these regulations. The *Manual,* which is available to a student after he has been admitted, sets forth in more detail the procedures governing registration, changes in program, and graduation, and gives other information about the Graduate School which is useful to graduate students. Every student should secure a copy from the Dean's office soon after admission.

ADMISSION

An applicant for admission to the Graduate School should understand that graduate work is not a simple extension of an undergraduate program. It operates at a higher level, demands scholarship of a higher order, and emphasizes research and creativity, with a minimum of formal requirements and a maximum of student initiative and responsibility.

Applicants must recognize that staff, facilities, and other resources are limited so that not all qualified persons can be admitted. The number which can be accepted will vary with departments and from term to term. In some fields all vacancies will have been filled long before the deadline for submitting applications so that even outstanding students cannot be accepted. The objective of the Graduate School is to admit a graduate student body of high qualifications up to the limit of the University's resources to provide graduate programs of outstanding quality.

Admission is granted jointly by the Dean of the Graduate School and the department in which the student plans to do his major work. Blanks to be used in making formal application for admission can be obtained from the Graduate School office. Students from abroad need not use formal application blanks. All academic records, and explanation of the grading system used, should be submitted to the Graduate School Admissions Office. In general, a student may begin his graduate work in fall, winter, spring, or summer. Prospective students may write directly to the head of any department concerning graduate work in that specific field.

CREDENTIALS—An applicant for admission should provide complete credentials, in duplicate, sent directly from all institutions to the Dean of the Graduate School at least two months prior to the opening of the term in which he plans to begin his graduate program. If the applicant has attended more than one institution, two official transcripts of the work covered at each institution are required. This applies to the complete academic record, both undergraduate and graduate.

A student with a slight deficiency in undergraduate preparation may be admitted and allowed to take a limited number of undergraduate courses to make up the deficiency while proceeding with his graduate program. Courses taken for this purpose do not, of course, apply toward the requirements for an advanced degree.

UNQUALIFIED ADMISSION—For unqualified admission to the Graduate School an applicant must have received a baccalaureate degree from an accredited institution, earned under residence and credit conditions substantially equivalent to those required by The Pennsylvania State University. He must have maintained during his junior and senior years a minimum grade point average equivalent to 2.50 on The Pennsylvania State University grading scale (approximately half B and half C). Finally, he must ordinarily have completed in a satisfactory manner a certain minimum of course work in designated areas, the specific courses and amount of required work depending upon the field of advanced study which the student proposes to enter. The specific courses and the total number of undergraduate credits required can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. The minimum grade point average of 2.50 during the last two

undergraduate years is a general requirement of the Graduate School. Individual departments may require a higher average for admission in their fields.

The above requirements apply particularly to the student who has recently completed an undergraduate program and is about to begin graduate study. An applicant who has obtained a graduate degree at a recognized graduate school will be evaluated largely on the basis of the graduate record.

Admission may be granted to applicants whose credentials are not complete at the time of application because the baccalaureate degree has not yet been conferred, grades for the current term are not yet available, etc. Such admission is subject to cancellation if the complete credentials, on arrival, do not meet the requirements for admission. In the interim, certification of any earned credits will be withheld. If admission should, for any reason, be canceled, the student is thereby automatically dropped from the Graduate School and as a consequence will be required to cease attending any 500-level courses for which he may have registered. He may continue to attend courses below the 500 level provided he applies for and is accepted for registration as an adjunct student.

CONDITIONAL ADMISSION—When a department has space for additional students, an applicant whose grade point average is below 2.50 may be admitted conditionally for one term under the following circumstances: He must have had at least one year of significant experience after receiving the bachelor's degree and be recommended for admission by his major department. The applicant's credentials must be on file in the Graduate School office at least three months before the proposed date of registration. He must devote full time (8-10 credits) to his studies during the term for which he is conditionally admitted unless he is a student at one of the Graduate Centers or in a comparable situation where a full-time program is not available. In the latter case he may continue on a part-time basis until the equivalent of a full term has been completed. At the end of the sudent's first term (or equivalent first term in the case of a part-time student) his conditional admission will terminate. If an average grade of 3.00 has been earned, he may continue as a student with unqualified admission. If an average of 3.00 has not been attained, the student may not register again as a graduate student.

ADVISERS—To assist the student in planning his program, the head of his major department will designate a member of the faculty to serve as adviser. It is the student's responsibility to secure the name of his adviser from the department head and to seek a conference before registration.

ENGLISH PROFICIENCY OF FOREIGN STUDENTS—Entering graduate students from countries other than the United States are required to demonstrate high level competence in the use of the English language, including reading, writing, speaking, and listening. Upon arrival at the University, such students are requested to report to the Office of International Student Affairs, where an appointment for the English language proficiency interview will be made. Students with an obviously good command of English will be exempted from formal testing; others will be scheduled for a series of proficiency tests. Remedial work will be prescribed as indicated by the tests.

GUESTS OF THE UNIVERSITY—The President, on recommendation of the Dean of the Graduate School, will welcome as guests holders of earned doctor's degrees who may be visiting the University Park Campus for purposes of noncredit study. Guest privileges apply to persons holding the degree from The Pennsylvania State University or other accredited colleges and universities. Guests may attend seminars and courses and, if space and facilities are available, carry on research. There will be no charge except for laboratory expenses. Arrangements should be made in advance with the Dean of the Graduate School.

UNDERGRADUATE STUDENTS—A senior student of The Pennsylvania State University lacking not more than 4 credits for graduation may be admitted to the Graduate School. This limit may be increased to 8 credits in the case of a student with an average of at least B (a grade point average of 3.00). Any senior with a 3.50 grade

point average may be admitted to 500-level courses with the consent of the instructor; other undergraduate students with a B average or better may be admitted to such courses with the consent of the instructor and the Dean of the Graduate School.

In certain cases undergraduate students may subsequently apply credits they have earned in 400 and 500 series courses toward an advanced degree at Penn State. Upon admission to the Graduate School such credits as are relevant to the graduate field of study and were not used to satisfy undergraduate requirements will be entered on the student's graduate transcript. These may then be applied toward an advanced degree provided they are acceptable to the major and minor departments. The time limitation on the completion of a master's degree program applies to these as well as to other credits.

STUDENT CONDUCT

The University expects that students will conduct themselves in accordance with the standards normally followed by educated men and women and in accordance with the laws of the nation, state, and borough. The right is reserved to sever at any time the University connection of any student whose influence is found to be injurious to the standard of morals and scholarship of the student body, or whose conduct is prejudicial to the name of the University.

UNSATISFACTORY SCHOLARSHIP

A graduate student who fails to maintain satisfactory scholarship or to make acceptable progress in his degree program will be dropped from the University. Action may be initiated by the department or committee in charge of the graduate major or by the chairman of the student's doctoral committee.

CLASSIFICATION

At the time of admission to the University a student is classified as a graduate, adjunct, or undergraduate student depending upon his objectives and qualifications. A graduate student may be admitted either as a degree student or a non-degree student depending upon his objectives. After admission to one of these categories, any change to the other must be arranged through the Graduate School Office.

DEGREE STUDENTS—Persons who plan to become candidates for advanced degrees at The Pennsylvania State University and who have been formally admitted for advanced study in a particular field are designated as degree students. The program of study is developed under the guidance of an adviser appointed by the head of the student's major department.

A degree student who has passed a candidacy evaluation is classified as a doctoral candidate.

NON-DEGREE STUDENTS—An applicant who meets all requirements for admission to the Graduate School, but who does not wish to work for an advanced degree at this institution, may arrange for a program of work as a non-degree student. This classification includes any who plan to transfer credits to another institution and those who plan special programs of study not leading to an advanced degree. The number of non-degree students who can be admitted is limited, and it is increasingly difficult to provide for them because of the limitation of total enrollment. Preference is given to students in degree programs.

If a non-degree student wishes to consult an adviser, one will be appointed upon request to the department head most closely associated with the student's field of interest. The student's status and standing will be reviewed by the Dean of the Graduate School at each registration. He may remain a non-degree student longer than one term only with the permission of the Dean, and for definite and good reasons.

ADJUNCT STUDENTS—An adjunct student is not a graduate student, inasmuch as he has not been admitted to the Graduate School, and may not register for graduate courses or research (500 and 600 series) without permission of the Dean of the Graduate School. An adjunct student may register for 400-level courses provided he has attained at least junior standing in college.

Credits earned as an adjunct student may not ordinarily be applied subsequently toward an advanced degree.

REGISTRATION

The responsibility for being properly registered rests with the student. At least until his program is near completion, he is expected to register for each term in which he proposes to do either course work or research toward his thesis, whether it be on or off campus. In the case of research, the number of credits shall be determined by the amount of time required for the investigation, one credit representing the equivalent of one week of full-time work. In the later stages of his program the situation will determine the requirements for the student's registration.

CONTINUITY OF REGISTRATION—A student who registers at University Park without interruption for each of the three terms in the September to June interval, for all four terms each year, or for each summer term is considered to have maintained a normal continuity of registration.

Anyone who has interrupted such a normal sequence and now plans to register for work at the University Park Campus is required to apply to the Dean of the Graduate School at least one month before the time of registration for permission to resume study.

The policy may be summarized for any specific term as follows:

Summer Term—Application required unless the student was registered at University Park for the preceding spring term or the preceding summer term.

Fall Term—Application required unless the student was registered at University Park for the preceding summer term or the preceding spring term.

Winter Term—Application required unless the student was registered at University Park for the preceding fall term.

Spring Term—Application required unless the student was registered at University Park for the preceding winter term.

PROCEDURE—For each registration the student, in consultation with his adviser, prepares a schedule of courses and research designed to fit his individual needs. The credit load will be reviewed by the Dean of the Graduate School at the time of registration. The registration process is completed in the manner specified for all students at the University.

Under certain conditions credit may be earned by work done away from the campus. A student contemplating such work should inquire of the Dean of the Graduate School about the procedures and conditions. The student must assume responsibility for the registration process, but the operation can be handled by mail. Registration must be completed before the close of central registration at University Park.

A student must register for courses audited as well as for those taken for credit.

REGISTRATION NEAR THE COMPLETION OF A PROGRAM—A candidate for the Ph.D. degree who is following the new regulations, which went into effect in the fall term 1967, is required to register continuously (at least three terms per calendar year) from the time he has both passed the comprehensive examination and met the three-term full-time academic requirement until his thesis is accepted by his doctoral committee, regardless of whether he is working on his thesis during this interval. These candidates are also required to be registered for the term in which they graduate.

Other doctoral candidates and master's students may be required to register for a

normal credit load because of their appointment status. If not, and if they have earned more than 90 or 30 credits, respectively, and have met the requirements for their degrees except for the completion of the thesis, these students may register for as few as two credits per term. A student who has met the minimum requirements for his degree and is now completing his research and thesis writing off-campus is not required to register, even if he comes to the campus several times each term to see his adviser.

A student, other than one following the new Ph.D. requirements, is not required to register for his final term in order to graduate or in order to make minor revisions to his thesis and/or to take a final examination for his degree.

TIME OF REGISTRATION—Registration days are indicated in the calendar at the beginning of this bulletin.

A student is expected to complete his registration during the officially designated period and to attend the first meeting of all classes in which he is enrolling. If this is impossible because of some emergency or unusual circumstance beyond his control the student may be granted permission by his instructor to miss a few class meetings it being understood that work missed will be made up subsequently. Under these conditions the Dean of the Graduate School may grant the student permission to register late. In general, a student who receives permission to register late will be required to reduce his program in proportion to the length of time he has been absent.

Regardless of when he may begin attending classes, a student who fails to complete the process of registration within the officially designated registration period will be liable for the late registration charge.

LOADS, ACADEMIC AND EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule in planning his academic program.

The University takes the position that the facilities of the Graduate School should be made available only to students who can profit from their Graduate School experience to a maximum extent. Therefore the Graduate School reserves the right to deny admission or registration to part-time students who (a) propose schedules of few credits which seem to reflect little real interest in graduate work or would not seem to require serious effort, or (b) wish to carry overloads of such proportion as to handicap them seriously in achieving maximum quality in their graduate work.

"Doing graduate work" means more than doing what is required in courses or in research. It means living in a scholarly atmosphere and seriously engaging in scholarly pursuits. It means profiting from hearing visiting scholars and artists and from engaging in discussions, both formal and informal, with faculty members and fellow students. It should mean leisure time for reflection and for exploring fields related to, although not directly a part of, one's specialty. Overloads make it difficult and often impossible to do graduate work so conceived. Hence the following "protective" schedule of permitted loads for employed students has been adopted:

EMPLOYMENT	ACADEMIC LOAD
0 hours per week	8-10 credits allowed
10 hours per week	7- 9 credits allowed
20 hours per week	5- 7 credits allowed
30 hours per week	4- 5 credits allowed
40 hours per week	1- 4 credits allowed

This means, for example, that anyone working twenty hours per week (about half-time) whether as a half-time graduate assistant, as an employee on campus, or as an employee off-campus, will be limited in the amount of graduate work for which he may register to about three-fifths of a normal full-time load (i.e., to 5-7 credits). The word "employment" is used in a very general sense and includes work for indirect compensation, such as housekeeping, working in the family business, maintaining a

large vegetable garden, etc. Hence, all students who are thus employed will be expected to adjust their academic loads accordingly. Exceptions, in the case of students who have demonstrated unusual ability, must be arranged with the Dean of the Graduate School at the time of registration. (See also Visiting and Auditing Classes.)

A student holding a fellowship, graduate assistantship, or scholarship may not accept employment of any kind for service beyond that specified by his appointment.

VISITING AND AUDITING CLASSES—A graduate student who wishes to attend classes without receiving credit may secure permission either to visit or to audit courses during a term for which he has registered.

As a visitor, a student may attend classes with the approval of the instructor but may not claim the usual privileges of class membership such as participating in discussion, doing practicum work, or taking examinations. He does not register for the privilege of visiting, nor does any record appear on his transcript.

As an auditor, a student may participate in class discussion, do practicum work, take examinations, and generally share the privileges of a class member. The student registers in the same manner as if he were taking the course for credit and pays the same fees. He receives no credit and cannot subsequently secure credit for work done in the course.

A student who, because of his status as a graduate assistant or fellow, is required to register for a certain minimum number of credits is not permitted to count those courses for which he is registering as an auditor for this purpose. The 1G and 2G language courses are an exception. Beyond the required minimum he may register for credit or audit but may not exceed the normal maximum without special permission.

In general, students are encouraged to visit classes rather than to register for a course as auditors. However, visiting is not permitted in German 1G and 2G.

In the 1G and 2G courses offered by the language departments, no distinction is made between registering for credit and for audit in considering loads. If the student does not have a reasonable background in the language, he will be required to count the course as part of his permissible load regardless of whether he registers for credit or for audit. If he has had the language before and is taking the course as a refresher, he may, with the permission of the Graduate Dean, take the course as an overload regardless of whether he registers for credit or audit.

SELECTIVE SERVICE—A request for deferment must be addressed to the local board by the student himself. The University can supply local boards with information needed in support of a request for deferment.

To have his local board informed of his formal admission to the Graduate School, a student must supply the essential Selective Service information and request the Records Officer to inform the board.

To have his local board informed of his registration and status as a student, a new graduate student must request the Records Officer to so inform the local board. If so requested, a report will be sent shortly after the beginning of the first term for which the student registers. A student is certified to be a full-time student insofar as Selective Service is concerned if he schedules at least 8 credits (auditing a course does not count), or if he holds an appointment as a quarter-time or half-time graduate assistant, or if he is serving an internship or holding a traineeship under approved conditions.

If at any time a student changes his status from full-time to part-time, fails to make satisfactory progress, or makes a drastic change in his declared goal, his local board will be notified. If a student changes his status from part-time to full-time and wishes the local board to be informed, he must request the Records Officer to do so. When a student receives a master's degree, it will be assumed his program is terminated, and his board will be so informed unless there is clear prior indication in the Records Office of the student's intention of proceeding with a doctoral program.

At the end of each spring term the Records Office reports to the local boards the status of all graduate students for whom a report was made during one of the three previous terms.

GRADING SYSTEM

A grade is given solely on the basis of the instructor's judgment as to the student's scholarly attainment.

The following revised grading system is now in effect: Any one of five quality grades (A, B, C, D, F) may be given a graduate student for course work or for thesis research. The grade point equivalents are 4, 3, 2, 1, 0, respectively.

At the 400, 500, and 600 levels grades of A, B, and C denote graduate credit, whereas D and F are failing grades for graduate students, D being the normal failing grade. A grade of F indicates doubt in the judgment of the instructor of the student's potential for further graduate study.

A minimum grade point average of 3.00 for work done at this university is required for graduation in the case of all candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later.

In addition to the quality grades listed above, two symbols, "Def." (deferred) and "R," may appear on a student's transcript. If work is incomplete at the end of a term for a reason beyond the student's control, or if very little work remains to be done, the instructor may report "Def." in place of a grade, which will appear temporarily on the student's record.

In the case of thesis work, either in progress or completed, and certain courses approved by the University Senate, the instructor may report the symbol "R" in place of a grade. This symbol indicates that the student has devoted an adequate amount of time to the work scheduled but gives no indication of its quality. An "R" remains on the student's transcript permanently. If, after having submitted a series of "R" symbols, the instructor reports a grade of A, B, C, D, or F for a specific term, this grade is considered to apply to the preceding series of registrations and to denote the quality of that entire series.

GRADUATION

It is the responsibility of the student to inform the Graduate Recorder of his intention to graduate (by filing a diploma card) and to pay thesis fees at the beginning of the term in which he expects to receive an advanced degree. If he does not graduate that term, he must reactivate the diploma card by indicating to the Graduate Recorder the term in which he intends to graduate. Deadlines are given in the calendar found at the beginning of this bulletin.

See the *Manual for Graduate Students* for a detailed statement of procedure concerning graduation. Attendance at commencement exercises is expected, but permission to receive the degree in absentia may be granted by the Dean of the Graduate School.

All degrees conferred are tentative until final grade reports have been received, even though the student's name may have appeared in the commencement program.

TUITION AND CHARGES

The University reserves the right to revise the schedule of tuition and charges without further notice.

TOTAL TUITION FOR EACH TERM

University Park Campus—8 or more credits, total charge of $175 for Pennsylvanians and $400 for non-Pennsylvanians; 7 or fewer credits, $19 per credit for Pennsylvanians and $50 per credit for non-Pennsylvanians. These rates also apply to off-campus research and other approved individual study.

Graduate and Continuing Education Centers—8 or more credits, total charge of $155

for Pennsylvanians and $400 for non-Pennsylvanians; 7 or fewer credits, $17 per credit for Pennsylvanians and $50 per credit for non-Pennsylvanians.

Vocational Education Programs—7 or fewer credits, $25 per total program for all students (vocational education courses are indicated by "v" following the course number).

Tuition is the same for courses whether audited or taken for credit.

Any student who does not fulfill payment obligations promptly may be charged a late payment fee of $25. A student whose account is delinquent for more than ten days is subject to suspension from the University.

Whenever it appears that an applicant for admission is not domiciled in Pennsylvania, it is assumed that he is a non-Pennsylvanian. If the student who is thus admitted believes that his circumstances do not justify his classification as a non-Pennsylvanian, he may petition the Graduate Dean's office for reclassification.

When a petition for reclassification is made, the petitioner is required to present proof of a bona fide continuous domicile of the one admitted (or of his parents, if he is a minor) within the Commonwealth for a period of at least twelve months immediately preceding the date of such petition for reclassification; and, in addition, such other evidence as is pertinent to a complete review of his classification.

Any student who changes his domicile while attending the University is subject to reclassification effective at the beginning of the first term following the twelfth month after such change has taken place.

TUITION REFUND POLICY—Charges for tuition are refundable upon withdrawal from the University only in the event the student obtains an Official Withdrawal Form at the office of the Dean of the Graduate School and presents it, together with his current Certificate of Registration, at the office of the Fee Assessor no later than one calendar month after the effective date of withdrawal from classes. Students who meet these conditions are entitled to receive refunds of charges for tuition for the term in accordance with the following schedule:

> Refund of 80 per cent upon withdrawal before the end of the first week of the term (seventh consecutive calendar day from the first day of classes) and a decrease of 20 per cent for each week thereafter up to and including the fourth consecutive calendar week. No amount will be refunded for withdrawal after the fourth consecutive calendar week of the term.

The University will not release any refund of tuition until at least three weeks have elapsed from the date the payment was received. All refunds will be made by check and mailed to the student's home address.

SPECIFIC CHARGES—In addition to the foregoing tuition and charges, the following charges apply under special conditions and are to be paid independently:

Admission to the Graduate School	$ 10.00
Change of schedule, each change	2.00
French reading examination	6.00
Music, individual lessons	30.00 to 100.00
Privilege of late payment	25.00
Privilege of late registration	10.00
Special dissertation fee for Ph.D. candidates (601)	75.00
Special dissertation fee for Ph.D. candidates (611)	25.00
Thesis binding fee for master's candidate	10.50
Thesis microfilming and binding fee for doctoral candidate	45.50
Transcript of records (with seal), each copy	1.00

MOTOR VEHICLE CHARGES—Each graduate student who possesses, maintains, or operates a motor vehicle (including a motorcycle, motor bike, motor scooter, or any other motor-driven vehicle) in Centre County is required to register such vehicle with the Traffic Violations Officer during the registration period of each term. There is no charge for registration for students who do not desire campus driving or parking

privileges. Failure to register a vehicle renders a student liable for a fine of $15 for each offense.

A permit allowing limited driving and parking on the campus throughout the week costs $10 per term. A more restricted permit allowing driving and parking on the campus for evenings and weekends costs only $3.50 per term.

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

A graduate student planning to operate a motor vehicle in the State College area should secure a copy of the leaflet *Parking and Traffic Regulations* from the Traffic Violations Officer.

LIVING ACCOMMODATIONS

Eastview Terrace and Graduate Circle, both located on the eastern side of the campus, provide one- and two-bedroom apartments for married graduate students.

The Eastview Terrace apartments are fire-resistant, one-story, steel framework buildings. Forty-six one-bedroom units rent for $75 per month and thirty-two two-bedroom units rent for $85. Rent includes utilities except for electricity. Water is heated electrically. The units are unfurnished except for electric stove and refrigerator. For each two units, there is a utility room with two stationary laundry tubs and storage space.

Graduate Circle has 144 one-bedroom and 72 two-bedroom apartments in sixteen two-story buildings of brick and frame construction. The units rent for $82.50 and $92.50 per month, including all utilities. Each kitchen has a double stainless steel sink with disposal unit, a gas stove, kitchen cabinets, and an electric refrigerator, and each bedroom has a built-in chest of drawers; otherwise the units are unfurnished. There are no facilities for private washing machines in the apartments; however, coin-operated laundries at nominal fees are provided in five of the buildings throughout the area. A storage locker is also provided for each apartment at the laundry location.

Families with children of school age or with children who will become school age during the term of the lease cannot be considered for occupancy in Eastview Terrace and Graduate Circle. The one-bedroom apartments are designed for a husband and wife and the two-bedroom units for a family with not more than two children.

Atherton Hall, located near the Hetzel Union Building and reserved exclusively for single graduate men and women, provides residence hall room accommodations without food service. Double, single, or single occupancy of double rooms are available at $130, $145, and $155 per term, respectively. The Hetzel Union Building cafeteria and snack bar are available for meals.

Separate dining hall meal tickets for one of eight campus dining halls may be purchased for $190 per term. Twenty-one meals per week are served beginning with registration and ending with final examinations.

For application forms and information on apartments and residence or dining halls, contact the Assignment Office for Campus Residences, 101 Shields Building, University Park, Pa. 16802; telephone Area Code 814, 865-7501. Advance application to this office is essential.

Information on other living accommodations available in the community may be obtained through the Chamber of Commerce, 129 W. Beaver Ave., State College, Pa. 16801; telephone Area Code 814, 237-7644. The cost of apartments or rooms in private homes or lodging houses varies considerably, depending upon the type of accommodations desired, and arrangements can best be made by personal visit to the area.

Prospective graduate students should arrange for their accommodations well in advance of the beginning of classes because it may be very difficult to find convenient housing at the last minute.

STUDENT SERVICES

HEALTH CENTER—The services at the Ritenour Health Center are available to graduate students registered for 8 or more credits and to all graduate assistants, fellows, and other holders of graduate tuition grants.

Hospitalized students will be charged $10 per day during confinement. A nominal charge will be made for all drugs dispensed to hospitalized or dispensary patients. Consult the *Manual for Graduate Students* for details concerning facilities and services.

INSURANCE PROTECTION WHILE ATTENDING THE UNIVERSITY—The Pennsylvania State University is an instrumentality of the Commonwealth performing its function of education. It is not liable for the negligence of its officers, servants, and employees when in the exercise of public or governmental powers or in the performance of public or governmental duties incident to the general educational work of the University.

Therefore any student who desires insurance protection while in attendance at the University (1) against personal injury and/or (2) against loss of property by fire or theft should arrange personally for whatever insurance seems advisable.

HEALTH INSURANCE PLAN—A voluntary Accident and Sickness Insurance Plan with a variety of benefits is available to graduate students and their dependents, provided the student is eligible for the services of the Ritenour Health Center. For further information, call the local representative for the student insurance carrier (telephone Area Code 814, 238-6725), or write to Graduate Student Health Insurance Plan, Graduate School Office, 101 Willard Building, University Park, Pa. 16802.

PLACEMENT SERVICE—The University Placement Service, in cooperation with all the Colleges and departments of the University, assists both graduate and undergraduate students in finding appropriate employment upon graduation. In addition, services are extended to alumni. Among the services offered are: (1) career counseling concerning career planning, career opportunities, employer characteristics, and employment trends; (2) a library of information about employers, employment trends, and career opportunities; (3) the scheduling of interviews with employers visiting the campus; (4) an extended file of employment opportunities for which a student may apply by mail; (5) a listing of summer jobs and internships appropriate to the student's career interests; and (6) conducting of appropriate research. These services are closely coordinated with the Division of Counseling.

Contact is maintained with several thousand employers in education, industry, and government. Information concerning employment opportunities is routinely distributed to all academic departments.

The general placement section concentrates on employment possibilities in industry and government. The teacher placement section concentrates on administrative, teaching, and service opportunities in universities as well as in elementary and secondary schools.

RELIGIOUS PROGRAMS—The University seeks to serve the spiritual needs of its students and staff. General responsibility for religious activity on the campus rests with the University Coordinator of Religious Affairs. Individual organizations under the sponsorship of members of the Jewish, Protestant, and Roman Catholic faiths serve the student body. Many other religious organizations, including denominational and interdenominational groups, are active on the campus and in association with local churches.

STUDENT AFFAIRS—The Graduate Student Association is the official University-wide organization of graduate students. All students have membership in the Association, which promotes the general welfare and the academic interests of graduate students. It publishes the *Graduate School Newsletter,* helps to sponsor the Graduate School lecture series, and sponsors social functions.

MASTER'S DEGREES

The Graduate School recognizes a difference in purpose, which is reflected in the requirements, for two types of advanced degrees, academic and professional. Of the eleven master's degrees conferred, the Master of Arts and the Master of Science are academic in nature. The professional degrees conferred are Master of Administration, Master of Agriculture, Master of Business Administration, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forestry, Master of Public Administration, and Master of Regional Planning.

A degree is not conferred for a mere collection of credits. A well-balanced, unified, and complete program of study will be required, which may frequently exceed the minimum requirements specified below.

A student may meet the degree requirements by either full-time or part-time enrollment and by attendance in any combination of terms. The student who interrupts the continuity of his registration faces the possibility of not being granted permission to return.

GRADE POINT AVERAGE—A minimum grade point average of 3.00 for work done at this university is required for graduation in the case of all candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later.

TIME LIMITATION—All requirements for a master's degree, whether satisfied on the University Park Campus or elsewhere, must be met within six years or a period spanning seven consecutive summers.

ADMISSION—In addition to the general University requirements for admission set forth at the beginning of this bulletin, adequate undergraduate preparation is required in the field in which the applicant expects to pursue advanced work. The specific courses and the total number of undergraduate credits required in various areas will be determined by the choice of field and can be ascertained from the descriptive statement appearing under the major field heading in the latter portion of this bulletin. An applicant who meets the minimum grade point average but is deficient in course preparation may, under certain circumstances, be admitted to the Graduate School and allowed to make up the undergraduate deficiencies. Under these circumstances the program will require more than the minimum period of residence. An applicant for admission to the M.Ed. program in most major fields is required to have had at least 18 credits in education and related psychology, and in certain major fields may be required to have had practice teaching.

After a student has been admitted to a degree program, he should confer with the head of his major department concerning the appointment of an adviser. The general guidance of a master's candidate is the responsibility of an adviser, or of a committee appointed in a manner to be determined by the major department in which the student is specializing. The adviser or the committee assists the student in planning a program of study. Although the adviser is frequently the supervisor of the thesis, this is not necessarily the case.

Requirements concerning courses, language proficiency, minors, comprehensive examinations, and other matters are sometimes made by departments in addition to (but not in conflict with) the regulations of the Graduate School. For details the student should consult the head of the major department.

TRANSFER CREDIT—Subject to the limitations given below on the use of credits earned away from the University Park Campus, a maximum of 10 credits of high quality graduate work done at another institution may be applied toward a master's degree here.

The student should distinguish carefully between the transferability of credit and its applicability in a particular degree program. When transfer credits are accepted at the time of admission, the student is not really assured of their applicability in his program until he has consulted his adviser and the details of his graduate program have been worked out.

M.A. and M.S.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Arts and the Master of Science degrees have similar requirements, the general major area determining which degree is conferred. Programs for both degrees are strongly oriented toward research.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus or at the Milton S. Hershey Medical Center. A minor is not required of all candidates for the M.A. or M.S. degree. A department or committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his committee.

A minor consists of no fewer than 6 credits of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and minor fields.

The major department or the committee in charge of the major field is the judge as to the suitability of a field for the minor and of its relevance to the major. The minor department has the responsibility of accepting or rejecting students, advising on courses to be taken by the candidate in its field, examining the candidate in the area of studies he has undertaken in its field, and certifying that the minor requirements have or have not been met.

At least 18 credits in the 500 and 600 series combined must be included in the program. A minimum of 12 credits in course work (400 and 500 series), as contrasted with research, must be completed in the major field. A thesis is required of all candidates for the degree of Master of Science and of many candidates for the degree of Master of Arts. Details are given in the introductory paragraphs under the major field headings in the latter part of this bulletin. If a student is required to write a thesis, he must complete at least 6 credits of thesis research (600 or 610).

Those candidates who are not required to write a thesis must present a suitable essay or paper. Its nature and extent shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. The department may require one or more copies of such an essay for its library or other files.

A thesis is prepared under the direction of the department in which the candidate's major work is taken. Under certain conditions a student may complete the thesis off-campus. To do so he must make satisfactory arrangements in advance with his adviser and the head of his major department.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

M.Adm.—ADDITIONAL SPECIFIC REQUIREMENTS

This program is designed to meet the professional needs of practicing and potential administrators. A basic premise is that administration is a necessary function in all organizations and that it requires a common body of knowledge and skills regardless of its area of application. A total of 30 graduate credits is required—18 in the core courses and 12 in the area of specialization or option—with the majority of the courses at the 500 level. Four option areas are offered: business administration, engineering administration, public administration, and logistics administration. Each student is required to complete a research project in the field or in a laboratory in which he applies research methods and tests his solution through experimentation or simulation. The report must be of the quality, if not the theoretical depth, of a graduate thesis. After substantially completing the course requirements, a candidate must pass a comprehensive written and oral examination administered by a committee of graduate faculty members. The candidate will be expected to demonstrate his ability to

integrate knowledge of a specialized area with a broad understanding of the general field of administration.

The program is offered only at the Capitol Campus.

M.Agr.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Agriculture have a professional orientation and provide training for increased competence in the various fields of agriculture. They should be clearly distinguished from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which at least 12 must be in 500-level courses and the remainder in 400-level courses. A minimum of 20 credits must be earned on the University Park Campus, and at least 12 must be earned outside the candidate's major field.

In addition to credit requirements, a candidate must present a paper on a selected professional problem comparable in quality to a thesis in which he applies scientific methods to the solution of a problem. He must demonstrate ability to (a) formulate and state meaningfully the problem and objectives, (b) critically analyze the present state of knowledge of the problem, (c) acquire and analyze information to help solve the problem, (d) draw logical conclusions, and (e) interpret the relationship between the findings and professional problems. The paper will be evaluated by a committee appointed by the Dean of the Graduate School.

The candidate is required to pass a final examination administered by a committee of three faculty members appointed by the Dean of the Graduate School. At least one member of the committee must come from a department other than that of the candidate's major field.

M.B.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Business Administration are designed to develop advanced professional competence in the various fields of business administration. They should be distinguished carefully from the research-oriented programs which lead to the academic degrees of Master of Science and Doctor of Philosophy with a major in Business Administration.

The programs require a minimum of 36 graduate credits, of which at least 18 must be at the 500 level and at least 26 earned on the University Park Campus. Candidates who enter this program without undergraduate training in business administration may be required to take up to 30 credits of preparatory courses in addition to the usual graduate requirements.

Each candidate is required to present a project paper comparable in quality and scope of work to a graduate thesis.

Applicants for the various graduate programs in business administration are required to take the Admission Test for Graduate Study in Business given by the Educational Testing Service.

M.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Education provide preparation for increased professional competence in the several fields of education. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts or Master of Science. In most major fields the requirements for admission include 18 credits in education and related psychology.

A minimum of 30 graduate credits is required for the degree, of which at least 20

must be earned on the University Park Campus; at least 24 must be in course work.

At least 15 credits in 500-series courses is required except in those fields for which the Dean has approved the waiving of this requirement for an experimental period of five years.

MAJORS IN THE FIELDS OF EDUCATION—A student may major in one of the approved fields of education, such as elementary education, art education, or home economics education, and proceed under the guidance of the appropriate department of education.

A program of this type requires at least 6 credits to be earned outside the fields of education.

MAJORS OUTSIDE THE FIELDS OF EDUCATION—A student who is preparing to teach in a specific subject-matter field, such as geography, mathematics, or German, may choose such a field as his major and take the majority of his work in it under the guidance of the department offering that major. A student wishing to work in a broader area may choose a major such as biological science, earth sciences, physical science, or social studies and take at least 24 credits in the area under the guidance of the committee in charge of the major.

Each candidate is required to earn 6 credits in education as directed by the faculty of one of the approved graduate programs in education. The 6 credits may be taken in educational foundations, which includes courses in comparative education; history, sociology, and philosophy of education; and educational psychology.

THESIS OR PAPER—Six credits may be granted for an approved thesis. A candidate who does not elect to write a thesis is required to present an essay or paper. It must be of considerable proportion, indicating capacity to describe a serious intellectual experience adequately in writing, and giving unmistakable evidence of ability to formulate and state meaningfully the purpose of an investigation, study, critical analysis, or evaluation; to acquire and analyze information; to draw conclusions logically; and to relate findings to professional problems and practices. The nature and extent of such a piece of writing, whether it be required in connection with a course or independently of course work, and when it is to be undertaken shall be determined by the major department. The department shall report to the Dean of the Graduate School the title, the name of the faculty member under whom the student did the work, and whether the work was considered adequate. It is the right, but not the responsibility, of the department to require one or more copies of such an essay for its library or other files.

M.Eng.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Engineering provide training for advanced professional competence in the several fields of engineering. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science.

A minimum of 30 graduate credits is required, of which at least 12 must be earned in graduate courses (500 series).

A scholarly written report on a developmental study involving at least one area represented in the candidate's course work is required as an integral part of the program. The report must be comparable in its level of work and quality to a graduate thesis. The topic of the developmental study is subject to prior approval by the department in which the candidate's major work is taken, and preparation of the written report shall be under the direction of that department.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervisory committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

M.F.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Fine Arts provide training for increased professional competence in the several specialized areas of the arts. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Arts with a major in art, music, or theatre arts.

A minimum of 48 credits is required, of which at least 38 must be earned on the University Park Campus. The larger part of these credits should be above the 400 level, but the needs of the student shall be considered in arranging the best combination of courses and research for the preparation of the candidate in his particular field.

A professional project, either creative or interpretative, is required. This project shall include a monograph in support of the creative or interpretative aspect; such monograph shall represent a minimum of 6 credits on the 600 level.

M.F.—ADDITIONAL SPECIFIC REQUIREMENTS

The programs leading to the degree of Master of Forestry provide training for increased professional competence in the several specialized areas of forest resource management and forest products. They should be distinguished carefully from the research-oriented programs which lead to the academic degree of Master of Science with a major in forest resources.

A minimum of 30 graduate credits is required, of which at least 20 must be earned on the University Park Campus.

A candidate for the degree of Master of Forestry should choose one area for his major and one or two related areas for his minor. The proportion of credits to be taken in the major and minor fields of study will be determined in consultation with the student's advisory committee. It is expected that the larger part of the program shall be in graduate courses (500 series), but no specific number of credits in the 500 series is required.

Each candidate is required to submit an acceptable thesis based on at least 6 credits of thesis research.

M.P.A.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Public Administration is a professional degree for students who are planning careers in public administration at local, state, national, and international levels or with private and voluntary agencies. This program should be distinguished carefully from the research-oriented program which leads to the academic degree of Master of Arts with a major in political science in which the candidate may also specialize in public administration.

For the M.P.A. degree a minimum of 30 graduate credits is required, of which at least 6 must be devoted to either a thesis or an internship. Students with extensive government experience will write a thesis; others will serve an internship and write a critical review of the experience, the review to be comparable in quality to a thesis. A comprehensive final examination will be required of all students, the examination to be written, oral, or both.

No work for this degree is required to be done specifically on the University Park Campus provided the major department or supervising committee and the Dean of the Graduate School agree that a complete program of study can be pursued at an established Graduate Center of The Pennsylvania State University.

The degree is a terminal one, and credits earned in the program may or may not be applicable, even in part, toward a doctorate.

M.R.P.—ADDITIONAL SPECIFIC REQUIREMENTS

The Master of Regional Planning is a professional degree for students interested in a coordinated attack on the problems of community development and resource management. The program is intended to acquaint the student with rational programs of spatial allocation of land uses and facilities, maintenance of cultural and aesthetic values, and legal and governmental techniques for their implementation.

A minimum of 45 graduate credits is required, of which at least 35 must be earned on the University Park Campus. At least 36 credits are required in planning courses, of which 9 will be devoted to a group regional planning project or a problem-oriented thesis. A student who does not submit a thesis will present a project report, comparable in quality and scope to a graduate thesis.

DOCTORAL DEGREES

The Doctor of Philosophy, an academic degree, and the Doctor of Education, a professional degree, are conferred by the University. Recognized as different in purpose, the two programs consequently have different requirements in certain respects.

ADMISSION—A student who has been admitted to the Graduate School and has been accepted by the department or committee in charge of a major field in which the doctorate is offered may begin working toward a doctor's degree. However, he has no official status as a doctoral student and no assurance that he will be accepted as a doctoral candidate until he has passed a candidacy examination. This examination is administered by the major department and is given early in the student's program.

There are no specific admission requirements in education and related psychology for the degree of Doctor of Education unless specified by the department or committee in charge of the particular major field. When such requirements do exist, they are listed in the introductory paragraphs under the major field headings in the latter part of this bulletin.

GENERAL REQUIREMENTS—No specified number of courses completed or credits earned will assure attainment of the doctorate. The general requirements are based upon a period of residence, the writing of a satisfactory thesis, and the passing of a comprehensive and a final oral examination. A doctoral program consists of such a combination of courses, seminars, and individual study and research as meets the minimum requirements of the Graduate School and is approved by the doctoral committee for each individual student.

A master's degree is not a prerequisite for the doctorate. However, the first year of graduate study leading to the Ph.D. may be substantially the same as that provided for the M.A. or M.S. degree. Similarly the first year of the D.Ed. program may be essentially the same as that provided for the M.Ed.

GRADE POINT AVERAGE—A minimum grade point average of 3.00 for work done at this university is required for admission to the comprehensive examination and for graduation in the case of all candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later.

TIME LIMITATION—A student who was formally accepted as a doctoral candidate on or after June 1, 1963, is required to complete his program within seven years from the date of his acceptance as a candidate. A student who was admitted to doctoral candidacy, formally or informally, prior to June 1, 1963, is required to complete his program before July 1, 1971.

OFF-CAMPUS AND TRANSFER CREDITS—Subject to the approval of his adviser and the head of his major department, a student may register for research to be done away from the University Park Campus.

With the approval of his committee, a candidate may apply toward the minimum requirements of a doctor's degree a maximum of 10 credits earned in Continuing Education classes or at the Commonwealth Campuses of The Pennsylvania State University. Credits so earned as a part of a master's degree program must be included in the limit of 10.

A maximum of 30 credits beyond the baccalaureate at an approved school not granting the doctorate in the student's major field may be accepted by the Graduate School in partial fulfillment of the requirements for a doctoral degree at The Pennsylvania State University. A maximum of two full academic years of work (60 credits) beyond the baccalaureate at a graduate school which grants the doctorate in the candidate's major field may be accepted here to apply toward doctoral degree requirements. Work beyond the master's will not be transferred if taken more than five years before beginning work for the doctorate at Penn State. Credits transferred will apply toward meeting degree requirements only if judged by the doctoral committee to be appropriate to the candidate's program of study.

ADVISERS AND DOCTORAL COMMITTEES—After a student has been admitted to a degree program, he should confer with the head of his major department concerning departmental procedures and the appointment of an adviser. Arrangement and approval of the details of the student's term-by-term schedule is the function of the adviser. This person may be a member of the doctoral committee or someone else designated by the head of the major department for this specific duty.

General guidance of a doctoral candidate is the responsibility of a doctoral committee consisting of four or more members of the Graduate Faculty. One member shall be from outside the candidate's major field. It is appointed by the Dean of the Graduate School, upon recommendation of the head of the major department, after the student is admitted to candidacy. At his discretion, the Dean may add other members to the committee. The supervisor of the candidate's thesis will usually, but not necessarily, be designated as chairman. The chairman must hold senior membership in the Graduate Faculty. An associate member may not exclusively supervise the research for a doctoral candidate, but he may serve with a senior member as co-chairman of the committee.

The doctoral committee is responsible for establishing the broad outline of the student's program and should review the program as soon as possible after his admission to candidacy. It will prepare, give, and evaluate the candidate's examinations, and supervise and approve his thesis. A favorable vote of at least two-thirds of the members of the committee is required for passing a comprehensive or a final oral examination. If a candidate fails an examination, it is the responsibility of the doctoral committee to determine whether he may take another examination.

The committee will also notify the Dean when the candidate is ready to have his comprehensive and his final oral examination scheduled and will report the results of these examinations to the Dean.

LANGUAGE AND COMMUNICATION COMPETENCE—A candidate for the degree of Doctor of Philosophy is required to demonstrate high-level competence in the use of the English language, including reading, writing, listening, and speaking. Proficiency is expected at the time of admission to the Graduate School and must be achieved before admission to candidacy.

In addition to demonstrating competence in English, each candidate for the Ph.D. must meet the language and communication requirement which has been established by his major department with the approval of the Graduate School Committee on Languages and Communication Skills.

If a candidate is to be examined for a reading knowledge of a foreign language by one of the language departments, he must report his intention to take the examination to the secretary of the language department by the end of the first week of classes

for the term during which he wishes to take it, except in the case of French. This date is one week prior to the examination date. The examination will be administered on dates announced in the graduate calendar at the beginning of this bulletin.

Candidates for the D.Ed. degree may be required by their major departments to demonstrate competency in foreign languages, but there is no Graduate School requirement.

COMPREHENSIVE EXAMINATION—When a candidate for the Ph.D. or D.Ed. degree has substantially completed his course work, he is required to take a comprehensive examination covering his major and minor fields of study.

A candidate for the Ph.D. must have satisfied the language and communication requirements before taking the examination.

All candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later are required to have a minimum grade point average of 3.00 for work done at this university at the time the comprehensive examination is given.

The examination is officially scheduled and announced by the Dean of the Graduate School upon recommendation of the doctoral committee. It is given and evaluated by the doctoral committee and may be either written or oral, or both. A favorable vote of at least two-thirds of the members of the committee is required for passing. In case of failure it is the responsibility of the doctoral committee to determine whether the candidate may take another examination. The results are reported to the Dean of the Graduate School, and will be entered on the candidate's official record.

When a period of more than five years has elapsed between the passing of the comprehensive examination and the completion of his program, the student is required to pass a second comprehensive examination before the final oral examination will be scheduled.

FINAL ORAL EXAMINATIONS—The doctoral candidate who has satisfied all other requirements for the degree will be scheduled by the Dean of the Graduate School, on recommendation of the doctoral committee, to take a final examination. Normally the final oral examination may not be scheduled until at least three months have elapsed after the comprehensive examination was passed, although the Graduate Dean may grant a waiver in the case of an outstanding student. The deadline for holding the examination is seven weeks before Commencement.

The final examination is oral, open to the public, and related in large part to the thesis; but it may cover the candidate's whole field of study without regard to courses that have been taken either here or elsewhere.

A favorable vote of at least two-thirds of the members of the committee is required for passing. The results of the examination are reported to the Dean of the Graduate School and will be entered upon the candidate's official record. If a candidate fails, it is the responsibility of the doctoral committee to determine whether he may take another examination.

Ph.D.—ADDITIONAL SPECIFIC REQUIREMENTS

The degree of Doctor of Philosophy is conferred in recognition of high attainment and productive scholarship in some special field of learning as evidenced by (1) the satisfactory completion of a prescribed period of study and investigation, (2) the preparation of a thesis involving independent research, and (3) the successful passing of examinations covering both the special subject and the general field of learning of which this subject forms a part.

In the fall term 1967 a revised set of requirements for the Ph.D. went into effect. A student who, by the end of the summer term 1967, had earned 45 or fewer graduate credits which were applicable toward his degree follows the new requirements.

RESIDENCE REQUIREMENTS—There is no required minimum of credits or terms of study, but over some twelve-month period during the interval between admission to candidacy and completion of the Ph.D. program the candidate must spend at least three terms (which may include the term in which the candidacy examination is taken) as a registered student, during which time he is engaged in full-time academic work on the University Park Campus or at the Milton S. Hershey Medical Center *and* is certified by his department as devoting half time or more to graduate studies and/or thesis research to meet his degree requirements.

After a student has passed the comprehensive examination and met the three-term requirement described in the preceding paragraph, no further registration for credit will be required by the Graduate School. He shall, however, maintain his status as a student by registering continuously (at least three terms per calendar year) until the thesis is accepted by his doctoral committee. This registration may be for courses for credit, for 601, or for 611, the latter two involving no credit and no tuition. In each case, the payment of the special dissertation fee for Ph.D. candidates is required.

OLD RESIDENCE REQUIREMENTS—A student who had earned more than 45 credits by the end of the summer term 1967 will be required to span a minimum of nine terms in full-time graduate study and research, or their equivalent in credits, for the Ph.D. At least 30 credits must be earned in residence at the University Park Campus.

For a period of three terms, two of which must be consecutive, the Ph.D. candidate must limit his work load to half-time at most, the balance of his time being devoted to graduate study.

A graduate assistant or research assistant who is a candidate for the doctorate, has passed the comprehensive examination, is registered for the maximum allowable credit load, and is certified by his department as devoting all his time to studies and thesis research to meet his degree requirements may be regarded by the Dean of the Graduate School as a full-time student for a period not exceeding one calendar year. Such a student will be considered to earn the equivalent of 10 credits per term, and three such terms will meet the minimum residence requirement for the Ph.D.

CANDIDACY EXAMINATION—This examination is administered by the major department. For a student following the new requirements, the examination may be taken after he has earned at least 12 credits in graduate courses beyond the baccalaureate. It should be taken early in his program.

For students following the old requirements, it is to be given near the end of the first, or at the beginning of the second, year of graduate work, including that done for the master's degree and work done elsewhere as well as here (i.e., at about the time he has earned a total of 30 graduate credits). A student transferring from another graduate school with 30 or more transfer credits must take this examination before he has earned more than 10 credits here.

MINOR FIELDS—A Ph.D. candidate is not required by the Graduate Faculty to have a minor field of study. However, a department or a committee in charge of a major field may require a candidate to offer work in a minor field, or a student may elect such a program with the permission of his doctoral committee.

A minor consists of no fewer than 15 credits, including those applied toward the master's degree, of integrated or articulated work in one field related to, but different from, that of the major. A minor program must meet the approval of the departments or committees responsible for both the major and the minor fields.

THESIS—The ability to do independent research and competence in scholarly exposition must be demonstrated by the preparation of a thesis on some topic related to the major subject. It should represent a significant contribution to knowledge, be presented in a scholarly manner, reveal an ability on the part of the candidate to do independent research of high quality, and indicate considerable experience in using a variety of research techniques. The contents and conclusions of the thesis must be defended at the time of the final oral examination.

The completed thesis, together with three separate copies of an abstract, must be filed in the office of the Dean of the Graduate School not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin*, which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

D.Ed.—ADDITIONAL SPECIFIC REQUIREMENTS

Programs leading to the degree of Doctor of Education are not limited to specific fields of education but, with the consent of the department or committee in charge, may also be offered in any other field appropriate to the preparation of teachers which has been approved for the doctorate, e.g., biological science, foods and nutrition, or English.

The degree is conferred in recognition of advanced preparation of a high order for work in the profession of education as evidenced by (1) satisfactory completion of a prescribed period of study; (2) ability to apply scientific principles in classroom instruction, supervision of instruction, administration, or as a consulting specialist in certain educational areas; (3) preparation of a thesis demonstrating ability to undertake an educational problem with originality and independent thought; and (4) successfully passing examinations, i.e., showing a satisfactory grasp of the field of specialization and its relation to allied educational areas.

RESIDENCE REQUIREMENTS—A minimum of nine terms of full-time graduate study and research, or their equivalent in credits—of which at least 30 credits must be earned in residence at the University Park Campus or the Milton S. Hershey Medical Center—is required for the D.Ed. degree. The D.Ed. candidate may meet the requirements by attending summer terms unless his major department requires a period of registration in other terms or in consecutive terms at University Park. A candidate may register for a maximum of 30 credits of research in absentia, but none of these may count toward the minimum of 30 credits which he is required to earn on the University Park Campus or at the Milton S. Hershey Medical Center. The maximum credit load permitted a student who is employed full time is 4 credits per term.

MAJOR AND MINOR FIELDS—The program of study includes a major and either a minor or a group of general studies. A majority of the courses offered in fulfillment of the requirements must be in the major field of study.

A candidate choosing a major outside the fields of education (such as speech, geography, or history) shall have a minor consisting of no fewer than 15 credits, including those applied toward the master's degree, in educational foundations, which includes courses in comparative education, educational measurements and statistics, educational psychology, history of education, and philosophy of education.

A candidate choosing a major in one of the fields of education must also choose either a minor or a group of general studies with the approval of the major department. In this case a minor consists of no fewer than 15 credits, including those applied toward the master's degree, in one field outside those of education. An acceptable general studies group consists of no fewer than 15 credits, including those applied toward the master's degree, in fields outside those of education considered by the major department to have significance and value for the candidate.

COMPREHENSIVE EXAMINATIONS—In addition to demonstrating a high level of competence in the subject matter of his major and minor fields, each candidate must show in his comprehensive examination that he is familiar with current theories of education; that he understands and can apply the techniques and the findings of educational research so far as they bear upon the teaching of his subject; that he is prepared to read understandingly and contribute to the technical and professional literature in his field; and that he can criticize his own procedures in the light of

historical trends and practices in this and other countries. Command of the tools for a thorough study of the problems of education is necessary and must include familiarity with statistical methods. For certain students the requirements may include a reading knowledge of one or more foreign languages.

All candidates whose first registration for graduate study at this university occurred in the spring term 1964 or later are required to have a minimum grade point average of 3.00, for work done at this university, at the time the comprehensive examination is given.

THESIS—Evidence of a high degree of scholarship, competence in scholarly exposition, and ability to select, organize, and apply knowledge must be presented by the candidate in the form of a written thesis. The candidate must demonstrate a capacity for independent thought as well as ability and originality in the application of educational principles or in the development of new generalizations under scientific controls. A thesis may be based upon a product or project of a professional nature, provided scholarly research is involved. For example, it may be based upon the solution of a professional problem concerned with the development of a curriculum, or a product of creative effort related to education. However, in order to be acceptable as a thesis, the professional project must be accompanied by a written discourse demonstrating the nature of the research and including such theories, experiments, and other rational processes as were used in effecting the final result. The topic and outline of the proposed thesis must have the approval of the doctoral committee.

The completed thesis, together with three separate copies of an abstract, must be filed in the office of the Dean of the Graduate School not later than five weeks prior to the commencement at which the candidate expects to receive the degree.

A *Thesis Information Bulletin,* which gives details concerning format, paper, illustrations, and other items, may be obtained at the Graduate School office.

STUDENT AIDS

In every case in which a graduate assistantship, fellowship, grant-in-aid, or scholarship for the next academic year is offered to an actual or prospective graduate student, the student, if he indicates his acceptance before April 15, will have complete freedom through April 15 to submit in writing a resignation of his appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits him not to accept another appointment without first obtaining formal release for the purpose.

STATEMENT OF NONDISCRIMINATION

In the selection of individuals for all types of financial aids for graduate study, in which the University has partial or complete control of the selection process and administration of the program, the University will not discriminate on the basis of race, creed, color, or national origin of any applicant.

ASSISTANTSHIPS

Approximately 1,900 graduate assistantships are awarded annually. Most of these are half-time, but a limited number of quarter-time and three-quarter-time assistantships are available in some departments. An appointee may serve as an assistant in classroom or laboratory instruction, or in research or other work.

A prospective student should write directly to the head of his major department for information and application forms. Appointments are made upon the recommendation of the department head, subject to the student's admission to the Graduate School. Clear evidence of superior ability and promise is required. Reappointment to an assistantship requires a continuing demonstration of good scholarship.

The assistantships vary as follows:

QUARTER-TIME—The student may schedule 7-9 credits, receives a stipend in the range $270-$480 plus a grant-in-aid which covers tuition, will be required to give a maximum of ten hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

HALF-TIME—The student may schedule 5-7 credits, receives a stipend in the range $480-$1,020 plus a grant-in-aid which covers tuition, will be required to give a maximum of twenty hours of service per week for twelve weeks, and will be considered to be following a full-time course of instruction under Selective Service regulations.

THREE-QUARTER-TIME—The student may schedule 4-5 credits, receives a stipend in the range $810-$1,350 plus a grant-in-aid which covers tuition, will be required to give a maximum of thirty hours of service per week for twelve weeks, and will be considered a part-time student.

The credit load limits specified above may be increased or decreased for a specific term by arrangement with the Dean of the Graduate School, provided the credit load and the service load are properly balanced in each term and the total credit load over a series of terms is in conformity with the specified limits.

In addition to receiving a grant-in-aid to cover full tuition during the term of appointment, a graduate assistant who is completing three or more consecutive terms of service is entitled to apply for an extra earned grant-in-aid to cover tuition for the succeeding term without service if he is not receiving a scholarship or fellowship from another source during the term. To receive this privilege a student must obtain an extra earned grant-in-aid form from the head of the department in which he has held the assistantship and must follow the instructions on the form in making application.

A graduate assistant may not accept employment, either at the University or elsewhere, during the period for which service to the University is required under the appointment (twelve weeks per term).

A graduate assistant pays no fee for the privilege of driving and parking on the campus but is required to comply with student regulations concerning motor vehicles.

FELLOWSHIPS AND TRAINEESHIPS

More than five hundred fellowships and traineeships are awarded annually. Recipients must be superior students and are frequently required to have completed a certain minimum of graduate work before being eligible for an award. Fellows and trainees carry full-time graduate programs, receive stipends which vary with the awards, and usually receive grants-in-aid paid by the donors of the awards to provide for all tuition. They may not accept employment during the terms of their appointments (except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs), nor are they required to render any service to the University. In some cases a recipient will be expected to limit his research to a broad field specified by the donor. Recipients are required to pay specific charges, such as admission, late registration, change of schedule, and parking fees, and also the thesis binding and microfilming fee unless the latter is paid for by the donor of the award.

GRADUATE SCHOOL FELLOWSHIPS—A small number of fellowships, each paying a stipend of $2,500 for the fall, winter, and spring terms and providing a grant-in-aid to cover all tuition charges for these terms, are given by the University and are designated as Graduate School Fellowships. They are available to outstanding graduate students in any field, although, ability of applicants being comparable, some preference is given to students majoring in the humanities and social sciences.

Applications should be addressed to the Dean of the Graduate School and must be received by February 8 to be considered for the following fall, winter, and spring.

FELLOWSHIPS AND TRAINEESHIPS FROM SPECIFIC GRANTS TO DEPARTMENTS BY FOUNDATIONS, INDUSTRIES, AND FEDERAL AGENCIES—At least 230 such awards, with various stipends, are granted through individual departments. Information and application forms may be secured from the head of the major department concerned. The specific awards will vary somewhat from year to year, but the following are typical of those which were available for 1968-69:

Accountants Fund, Inc., Dissertation Fellowship—Available to a Ph.D. candidate in business administration who is preparing to teach accounting; stipend variable up to $5,000.

Amelia Earhart Fellowship—Available to a woman graduate student in aerospace engineering; stipend $2,400.

American Chemical Society Fellowship—Available to a graduate student in fuel science; stipend $2,280.

American Chemical Society Fellowships (2)—Open to graduate students in geochemistry, mineralogy, and solid state science; stipend $2,400.

American Cyanamid Fellowship in Chemistry—Available to a graduate student in chemistry for the final year of study leading to the Ph.D. degree; stipend $1,800.

American Iron and Steel Institute Fellowships (2)—Open to graduate students in geochemistry and metallurgy; stipend $2,400-$4,320.

Armstrong Doctoral Fellowship in Business Administration—Available to a Ph.D. candidate in business administration; stipend $3,100.

Armstrong Summer Fellowships in Chemistry (5)—Open to graduate students in chemistry; stipend $640.

Atomic Energy Commission Graduate Traineeships in Nuclear Reactor Operations and Utilization (5)—Open to graduate students in nuclear engineering. Stipends comparable to the AEC Special Fellowships.

Carborundum Corporation Fellowship—Available to a graduate student in mineral preparation; stipend $2,400.

Continental Oil Company Fellowship—Available to a graduate student in petroleum and natural gas engineering for studies in petroleum engineering; stipend $2,280.

Continental Oil Company Fellowship in Petroleum Economics—Available to a graduate student in mineral economics for studies in petroleum economics; stipend $2,280.

Diamond Alkali Company Foundation Summer Fellowship—Available to a graduate student in chemical engineering; stipend $600.

du Pont Fellowship—Available to a graduate student in mechanical engineering; stipend $2,430 per year (three terms).

du Pont Summer Fellowships (6)—Open to graduate students in chemical engineering; stipend $600.

Ernst and Ernst Fellowship—Available to a master's candidate in accounting; stipend $1,000.

Esso Research and Engineering Fellowship in Chemistry—Available to an advanced graduate student for one year of study leading to the Ph.D. degree; stipend $1,800-$2,200.

W. S. Elliott Fellowship—Available to a graduate student who is a Penn State graduate and is interested in engineering research; stipend $1,200.

Fisher-Price Fellowship—Available to an advanced graduate student in child

development and family relationships and especially interested in work with young children; stipend $1,950.

Ford Motor Company Fellowship—Available to a graduate student in mechanical engineering; stipend $2,430 per year (three terms).

General Foods Fund Fellowships (2)—Open to graduate students with a major in the College of Human Development; stipend for doctoral $3,000, for master's $2,000 for tuition and other expenses.

Gulf Oil Company Fellowship in Petroleum and Natural Gas Engineering—Available to a graduate student for work in petroleum production; stipend $2,400.

Hamilton Standard Fellowship—Available to a graduate of this university in aerospace, electrical, and mechanical engineering, engineering mechanics, or physics; stipend $1,800.

Haskins and Sells Foundation Fellowship—Available to a graduate student in accounting; stipend $2,500.

H. R. Imbt Services, Inc., Fellowship—For graduate work in civil engineering in the field of civil engineering construction; stipend $2,400.

International Business Machines Corporation Fellowship—Available to an outstanding advanced graduate student in any major when his doctoral research is amenable to treatment by a digital computer; stipend $2,400-$3,000. Apply to the Dean of the Graduate School.

International Lead Zinc Research Organization Fellowship—In support of research on the application of lead and zinc compounds to chemical, ceramic, electrical, and allied industries. Available to a student in ceramic science; stipend $3,000.

International Lead Zinc Research Organization Fellowship—In support of research on the physics and chemistry of lead and zinc compounds. Available to a student in solid state science; stipend $2,540.

Joseph M. Johnston Memorial Scholarship—Available to a student whose program is related to floriculture; stipend variable.

Marathon Oil Company Fellowship—Available to a graduate student in petroleum and natural gas engineering; stipend $2,280.

National Lead Company, Titanium Alloy Manufacturing Division Fellowship—In support of research on the chemistry and physics of titanium and zirconium compounds of interest to the chemical and ceramic industries; stipend $2,600.

National Steel Corporation Fellowship—Available to a graduate student in metallurgy; stipend $2,880.

Edward Orton, Jr., Ceramic Foundation Fellowship—Available to a student in ceramic science for studies relating to kiln-fired ceramic materials; stipend $2,400.

Owens-Illinois Fellowship—Available to a graduate student in ceramic science for studies in glass science and technology; stipend $3,000.

Pennsylvania Cooperative Fishery Unit Fellowships (3-4)—Open to graduate students in zoology; stipend $2,400-$2,460.

Pennsylvania Cooperative Wildlife Research Unit Fellowships (4)—Open to graduate students in forestry, zoology, and related fields; stipend $2,400.

Pennsylvania Electric Association Fellowship—For graduate work in mineral economics on potential markets for fly ash; stipend $2,400.

Pennsylvania Natural Gas Men's Fellowship—Available to a graduate student in petroleum and natural gas engineering for studies in gas technology; stipend $2,000.

Price Waterhouse Foundation Fellowship—Available to a Ph.D. candidate in accounting; stipend variable up to $5,000.

Radio Corporation of America Fellowship—Available to a graduate student in electrical engineering; stipend $2,100-$3,000 for nine months. May be supplemented for an additional three months on application.

Shell Companies Foundation Fellowships (2)—Open to advanced graduate students in two of these fields in rotation: chemical engineering, chemistry, and petroleum engineering; stipend $2,500.

Shubert Fellowship in Playwriting—Available to a graduate student in theatre arts; stipend $2,500.

SOCONY-MOBIL FELLOWSHIP—Available to a graduate student in chemical engineering; stipend $3,000-$3,500.

SPEER CARBON FELLOWSHIP—Available to a graduate student in fuel science for studies on carbon; stipend $2,680-$3,500.

SPRAGUE ELECTRIC COMPANY FELLOWSHIP—Available to a graduate student in ceramic science or solid state science; stipend $2,400.

STACKPOLE CARBON FELLOWSHIP—Available to a graduate student in fuel science for studies on carbon; stipend $3,600.

STACKPOLE FERRITE FELLOWSHIP—Available to a graduate student in ceramic science or solid state science; stipend $3,000.

STAUFFER CHEMICAL COMPANY FELLOWSHIP IN CHEMISTRY—Available to a graduate student in chemistry for research on organometallic compounds; stipend $1,800.

SUN OIL COMPANY FELLOWSHIP IN CHEMISTRY—Available to the incoming graduate student who is judged to offer the greatest promise for a successful career in chemistry; stipend $3,000.

SURFACE COMBUSTION FELLOWSHIP—Available to a graduate student in fuel science for studies in the field of gaseous combustion; stipend $3,600.

TEXACO FELLOWSHIP IN GEOPHYSICS—Available to a graduate student in geophysics; stipend $2,760.

UNION CARBIDE FELLOWSHIP—Available to a graduate student in mechanical engineering; stipend $2,430 per year (three terms).

UNION CARBIDE SUMMER FELLOWSHIPS (5)—Open to graduate students in chemical engineering; stipend $600.

U. S. OFFICE OF EDUCATION FELLOWSHIPS IN EDUCATION OF EXCEPTIONAL CHILDREN (26)—Open to graduate students being prepared as leadership personnel in the education of the mentally retarded and the emotionally disturbed and in special education administration; stipend $2,200-$3,200 plus dependency allowance. Apply to the head of the Department of Special Education.

U. S. OFFICE OF EDUCATION EXPERIENCED TEACHER FELLOWSHIPS IN GEOGRAPHY (15)—Open to secondary school teachers with at least one year of experience, preferably three years, who are released from their school systems and promise to return after the year's study; stipend $4,000 plus dependency allowance.

U. S. OFFICE OF EDUCATION FELLOWSHIPS IN SPEECH PATHOLOGY AND AUDIOLOGY WORK WITH THE SPEECH-HANDICAPPED (5); WORK WITH THE DEAF (4)—Open to graduate students specializing in these fields; stipend $2,200-$3,200 plus dependency allowance. Apply to the director of the Speech and Hearing Clinic.

U. S. OFFICE OF EDUCATION TRAINEESHIPS IN EDUCATIONAL PSYCHOLOGY (6)—Open to graduate students majoring in educational psychology and preparing for careers as educational research workers; stipend $2,400-$2,800 plus dependency allowance.

U. S. OFFICE OF EDUCATION PROSPECTIVE TEACHER FELLOWSHIPS IN FAMILY LIFE AND SEX EDUCATION (6)—Open to master's degree students majoring in child development and family relationships and preparing for teaching family life and sex education in elementary or secondary schools; stipend $2,000-$2,200 plus dependency allowance.

U. S. OFFICE OF EDUCATION, BUREAU OF RESEARCH, RESEARCH TRAINEESHIPS IN PHYSICAL EDUCATION AND RECREATION (8)—Open to graduate students pursuing the doctoral degree in preparation for careers in research; stipend $2,400-$2,800 per year plus dependency allowance.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN AIR POLLUTION (26)—Open to selected graduate students in the physical sciences, biological sciences, and social sciences; stipend $3,000-$3,600 plus dependency allowance. Applications and information available through the Center for Air Environment Studies.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN CLINICAL PSYCHOLOGY (18)—Open to selected graduate students in this area of psychology; stipend $1,800-$3,000.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN MICROBIOLOGY (4)—Open to selected graduate students in microbiology; stipend $2,400-$2,800.

U. S. PUBLIC HEALTH SERVICE TRAINEESHIPS IN PUBLIC HEALTH NUTRITION (5)—Open to selected graduate students in foods and nutrition; stipend $3,000.

U. S. Public Health Service Traineeships in Sanitary Engineering (5)—Open to graduate students in sanitary engineering; stipend $3,600-$5,000.

United States Steel Foundation Fellowship—Available to a graduate student in the College of Earth and Mineral Sciences for studies related to metallurgy; stipend $2,880.

U. S. Vocational Rehabilitation Administration Traineeships in Speech Pathology and Audiology (11)—Open to graduate students specializing in speech pathology and audiology; stipend $2,400-$3,400.

U. S. Vocational Rehabilitation Administration Traineeships in Vocational Rehabilitation Counseling (36)—Open to graduate students in counselor education who are specializing in vocational rehabilitation counseling; stipend $1,800-$2,000.

Veterans Administration Internships in Clinical Psychology (5)—Open to selected advanced graduate students in this area of psychology; stipend $3,500-$6,500, not including tuition and fees.

Walter Thomas Memorial Scholarship—Available to a student studying the nutrition of horticultural crops; stipend variable.

In addition, grants are available from governmental agencies, industrial concerns, foundations, and the armed forces for graduate study and frequently for support of investigations of particular problems. Some of these permit full-time study and carry the same exemptions as the fellowships listed above. Detailed information may be secured from departments.

EXTERNALLY SPONSORED FELLOWSHIP AND TRAINEESHIP PROGRAMS—Attention is directed to the following national programs, involving numerous fields of study, with which the University cooperates by providing local administration. (See statement on nondiscrimination, p. 60.)

Atomic Energy Commission Special Fellowships in Nuclear Science and Engineering—These fellowships are available to United States citizens who hold bachelor's degrees in engineering or physical science (chemistry, earth science, mathematics, or physics) and who have completed mathematics through ordinary differential equations. Applicants for first-year fellowships will be required to take the Graduate Record Examinations, designed to test aptitude and achievement, which are administered in January at a large number of centers in the United States and overseas. Before a fellowship appointment becomes effective, the fellow must be granted fellowship clearance by the Atomic Energy Commission and must be accepted by a participating university for study leading to an advanced degree. The deadline for filing applications for fellowships beginning in September is the first of the preceding January. Forms may be obtained from the NSE Fellowship Office, Oak Ridge Associated Universities, Oak Ridge, Tennessee. About 200 will be awarded.

National Defense Graduate Fellowships—Under Title IV of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education makes an allotment of three-year fellowships to approved institutions which have applied for them and designates the major fields among which the awards may be distributed. One purpose of these awards is to assist able graduate students who certify their interest in college or university teaching to obtain their doctorates, thus increasing the higher education teaching staff nationally. The program also aims to increase the development and utilization of doctoral degree training facilities and promote their wider distribution geographically.

Two-thirds of these fellowships in an institution must be awarded to students with no more than one-half year of graduate study by September; the remainder may be awarded to those who have completed no more than two years of graduate study by September. These awards compare favorably with the best fellowships available. The University had 220 students studying under these fellowships in forty-one different fields of the arts and sciences in 1968-69.

No institution knows until the fall of each year whether it will have any additional fellowships under this program for the following year. A senior or an interested graduate student should inquire from the head of his actual or anticipated graduate

major department. Applications will be made directly to the departments or graduate deans of institutions having programs in the desired field. Most institutions have application deadlines from February 15 to 20. Approximately 3,300 of these fellowships were awarded for 1968-69.

National Defense Modern Foreign Language Fellowships—Under Title VI of the National Defense Education Act of 1958, as amended, the U. S. Commissioner of Education allocates to institutions which have approved programs of study in certain languages of critical importance to the United States, and in the cultural areas related to these languages, graduate fellowships for the study of these languages and the related areas. The languages involved in this program are in general those not commonly taught in the United States. French, German, Italian, and Peninsular Spanish are excluded.

Applicants must give reasonable assurance that they will be available after graduate study for teaching a modern foreign language or a related study in a college in the United States or for such other public service as may be specified in the application materials.

Late in the fall the Commissioner of Education announces the institutions, the quotas of fellowships, and the specific language and area programs to which the fellowships are allocated. (For 1968 the announcement was made in January 1968.)

In 1968-69 the University had five in Russian language and area studies for majors in Slavic languages, in the Eastern European area program for students majoring in Russian, and for those majoring in economics, geography, history, or political science with emphasis on Eastern Europe but also studying a Slavic language. Write to the head of the department of one of these four departments or to the head of the Department of Slavic Languages.

Approximately 1,800 were awarded for 1967-68.

National Science Foundation Graduate Fellowships—The Graduate School cooperates in this program of prestige fellowships requiring outstanding credentials and available in the biological, engineering, mathematical, and physical sciences; anthropology; economics (excluding business administration); geography; history and philosophy of science; political science; psychology (excluding clinical); and sociology (excluding social work). Also included are interdisciplinary fields such as biophysics, geochemistry, meteorology, and physiology. These fellowships are used at the university of one's choice. Application is made during the fall to the Fellowship Office, National Academy of Sciences-National Research Council, 2101 Constitution Ave., N. W., Washington, D. C. 20418, which has charge of evaluating applicants for the Foundation. About 1,900 new awards were made for 1968-69. The application deadline for 1969-70 was December 6, 1968.

National Science Foundation Graduate Traineeships—This program was expanded in 1966-67 to include all the areas supported by the Graduate Fellowship Program mentioned above. The National Science Foundation awards training grants to various recognized universities to accelerate the output of graduate students in these fields and to help meet the nation's future needs for scientific and professional manpower. These grants permit a university to award a specified number of traineeships 80 per cent of which must go to first-year graduate students. These awards compare favorably with the best fellowships. In 1968-69 the University had ninety of these traineeships distributed through thirty-two areas supported by NSF. More will probably be available in many of the areas for 1969-70. No institution will know until the middle of January whether it will have any available. An applicant should write to the graduate dean at the institution of his choice, or to the head of the department in his graduate field. About 1,900 new awards were made for 1968-69.

National Science Foundation Science Faculty Fellowships—These awards are made to enhance the effectiveness of college faculty members who have at least three years' experience as full-time staff members teaching science, mathematics, or engineering mainly to undergraduates. They are awarded to those working for

Ph.D., or to those holding the degree and teaching in any of the fields supported by the NSF Graduate Fellowship Program. Tenure may be from three to fifteen months and can be spread over three successive summers. For information, write to the National Science Foundation, Washington, D. C. 20550. The application deadline for 1969-70 was October 7, 1968; about 275 awards were made.

U. S. Public Health Service Predoctoral Fellowships—Available to graduate students in anatomy, anthropology, behavioral sciences, biochemistry, biomedical engineering, biophysical sciences, biostatistics, botany, developmental biology, endocrinology, entomology, genetics, history of life sciences, medicinal chemistry, microbiology, nursing, nutrition, organic chemistry, pathology, pharmacology, physiology, social and psychological sciences, zoology, and air and water pollution. These fellowships are used at the university of one's choice and are more frequently awarded to second- or third-year graduate students. Prior to formal application a senior must have been admitted to a graduate school and have obtained a sponsor there who will supervise his training. Application should be made to the Career Development Review Branch, Division of Research Grants, National Institutes of Health, Bethesda, Maryland 20014, by October 1 for awards announced in February, by January 2 for June awards, and by April 1 for September awards. Approximately 2,000 are awarded annually.

Woodrow Wilson National Fellowships—Awarded by the Woodrow Wilson National Fellowship Foundation for first-year graduate study at the institution of one's choice to outstanding students who show a clear preference for a career in college teaching, especially in the areas of the humanities and social sciences. Science and mathematics majors will be considered; but they must also apply for National Science Foundation Fellowships, and, if one is received, the applicant must accept it in preference to the Woodrow Wilson award. Each student must be nominated by a professor in his undergraduate college. The nomination is sent to the regional representative of the Woodrow Wilson Fellowships for the area in which that college is located. An interested student should consult the dean or other official of his college, or write to the Woodrow Wilson National Fellowship Foundation, Box 642, Princeton, N. J. Nominations must reach the regional chairman by October 31 each year.

Instead of the thousand awards formerly made annually, only one hundred awards were made for 1968-69, selected from a Designate List of the top thousand applicants. The list of Designates will be sent to ten leading graduate schools to which the Ford Foundation is distributing over 41 million dollars for the next seven years to enable these institutions to support a certain number of graduate students throughout their complete doctoral programs, not just for one year. This prestige list of applicants will also be sent to all graduate schools which offer the Ph.D. in the humanities and social sciences. Those not accepted by the above schools will constitute a list of outstanding applicants for other graduate schools to consider.

OTHER AIDS

RESIDENT ASSISTANTSHIPS FOR MEN—A number of appointments are available to male graduate students to serve as resident assistants in the undergraduate men's residence halls. A resident assistant's responsibility is to work for the social, academic, and emotional adjustment of the undergraduate residents. Specialized training and experience in personnel work are helpful, although not essential. These appointments are for three terms (fall, winter, and spring). Remuneration is in the form of room, board, and full in-state tuition. A resident assistant may not hold a fellowship or an additional assistantship during the term of his appointment, nor may he engage in any other form of part-time employment. He may carry 7 to 9 credits per term. Requests for further information and application materials should be addressed to the Division of Residence Hall Programs, 117 Old Main, University Park, Pa. 16802.

SENIOR RESIDENT POSITIONS FOR WOMEN—Full-time salaried appointments as senior residents in undergraduate halls for women are available to qualified women graduate students. Responsibilities include working with student groups in a programming capacity, counseling, and supervising the residence hall during the evening. Preference is given to persons working for master's degrees in higher education, specializing in student personnel administration.

These positions permit the holders to take 4 graduate credits per term at reduced tuition. Appointments are made for the fall, winter, and spring terms. Special arrangements of hours of work and credits may be made for the summer term. It is thus possible to complete work for a master's degree in two calendar years.

Requests for information and application materials should be addressed to the Division of Residence Hall Programs, 117 Old Main, University Park, Pa. 16802.

GRADUATE GRANTS-IN-AID—Forty grants for full-time study are awarded each year on a term basis, providing for all tuition. They are available to any student on the basis of financial need and academic promise. A recipient is expected to carry a full program of graduate work but may accept employment with the University or another employer not to exceed ten hours per week, provided he reduces his academic load to 8 or 9 credits. Application for renewal of the grant-in-aid may be made for succeeding terms. The value of these grants to Pennsylvanians is $175 per term, to non-Pennsylvanians, $400 per term. A few grants are available for students beginning graduate study in the winter or spring term, if applications are filed six weeks before registration for that term.

Applications should be addressed to the Dean of the Graduate School and must be received by March 15 to be considered for the following summer or fall.

DU PONT TEACHING AWARD IN CHEMISTRY—To be eligible for the E. I. du Pont de Nemours and Company Postgraduate Teaching Assistant Award, a graduate student must be currently serving as a part-time teaching assistant and preferably should have had two years of experience in this capacity. The recipient receives $1,200 in addition to the regular stipend paid him as a teaching assistant.

THE RUTH YOUNG BOUCKE GRADUATE FELLOWSHIP—Established from the estate of Ruth Young Boucke, whose husband was for many years a professor of economics, this fellowship is available every other year to an outstanding graduate student on the same basis as the regular Graduate School fellowships, and selection is made by the Graduate School Committee on Fellowships and Awards. The stipend is $1,800 for a tenure of three terms plus a grant-in-aid for tuition.

JOHN W. WHITE FELLOWSHIPS—Awarded to two or three graduates of The Pennsylvania State University each year on the basis of scholarship, need, character and aptitude. The recipients may enroll in any approved college or university. Application is made to the Office of Student Aid, 121 Grange Building.

SCHOLARSHIPS—A number of scholarships furnished by outside agencies and organizations are awarded annually through individual departments. A request for information should be directed to the department head in the field of the student's major interest.

A.A.U.W. SCHOLARSHIP—The State College Chapter of the American Association of University Woman has established a modest scholarship which is awarded annually to honor an outstanding woman graduate student. The award does not include exemption from tuition. Nominations are made by departments.

LOANS ADMINISTERED BY THE UNIVERSITY—The Director of the Office of Student Aid has charge of all loans administered by the University, for both undergraduate and graduate students. Application forms may be obtained from his office in 121 Grange Building. Funds are available from three sources:

University Loan Funds have been established through the generosity of University organizations, alumni, faculty, staff, and friends. Graduate students without assistantships who are registered for full credit loads may obtain long-term loans, while

graduate assistants who are classified as full-time students by the Dean of the Graduate School may qualify only for short-term loans from these funds. Applicants must demonstrate a need for financial assistance in meeting University-related expenses and be United States citizens, except that international students may qualify for short-term loans if they can secure a responsible resident of Pennsylvania as cosigner of the note. The interest on long-term loans does not begin until after graduation and generally is at a low rate for the first two years.

National Defense Education Act Loan Funds are available for United States citizens from the federal government, this act having been expanded in the fall of 1964 to increase the amount allotted to each institution and to increase the ceiling on loans to graduate students to $2,500 per year. The forgiveness of half the loan over a five-year period for those entering teaching has been extended to college teaching and to teaching in private elementary and secondary schools, as well as to teaching in public elementary and secondary schools. Interest at 3 per cent does not start until nine months after the borrower ceases to be a full-time student. Repayment must then be made at the rate of no less than $15 per month.

The Alumni Graduate Student Loan Fund has been established through the efforts of the University Alumni Fund and contributions of Graduate School alumni who have received their bachelor's degrees elsewhere. The Graduate Student Association has also made sizable contributions to it. The purpose of this fund is to assist graduate students on a short-term loan basis in meeting somewhat unexpected financial obligations associated with receiving a degree, such as thesis typing, thesis binding and microfilming fee, job interview travel, etc. Students who have completed all required credits and are not registered, but are completing their theses and anticipating graduation at the next commencement, may qualify for these loans.

STATE HIGHER EDUCATION LOAN PLANS—A number of states have passed laws which enable them to set up agencies to guarantee loan agreements with commercial banks, enabling cooperating banks in those states to make long-term personal loans to qualifying students to help pay their college or graduate school expenses. This cooperation makes possible lower interest charges and longer repayment periods than are available for ordinary personal loans.

Pennsylvania has established the Pennsylvania Higher Education Assistance Agency for those who have been residents of Pennsylvania for one year prior to filing applications and are accepted for enrollment in approved institutions of higher education. A full-time graduate student may borrow up to $1,000 per year, the total not to exceed $7,500 during the entire period of his post-secondary education. To be eligible, a part-time graduate student must be enrolled for at least 6 credits and is limited to $500 per year. The federal government will generally pay the interest on behalf of the student while he/she is enrolled in school and the first 3 per cent of interest while the student is making repayment following graduation or withdrawal from school. Repayment of the principal of the loan is not required until the student leaves or graduates from school. Generally, to be eligible for the interest subsidy, the annual adjusted family income must be below $15,000 per year and the student must be enrolled in an eligible course of study in a nonprofit institution. A list of participating lending institutions is available from all secondary school counselors, school financial aid officers, or the Pennsylvania Higher Education Assistance Agency, Guarantee Loan Program, Towne House, Harrisburg, Pennsylvania 17102.

Residents of other states should inquire of their state education departments regarding the existence of similar plans. Practically all the states of the United States, and the District of Columbia, have such programs.

ASSURED EDUCATION PLAN—The University offers to sponsors (including parents) of students the Assured Education Plan, enabling them to pay out of current income, on a monthly basis, University bills for tuition, residence hall room and board, and all other items billed by the University. Life insurance and total and permanent disability insurance are a part of the plan for the sponsor up to his sixty-eighth and sixty-first birthdays, respectively. Payments are handled through the Gi-

rard Trust Bank, Philadelphia, Pa. Further information and application forms may be obtained from the Office of the University Bursar, 103 Shields Building. Signed agreements should be received well in advance of registration, since it takes at least three weeks for completion of arrangements.

STUDENT EMPLOYMENT—Many students depend upon part-time employment to help meet their expenses. A student who is thus employed, however, must recognize the time demands of his work schedule and will be required to adjust his academic load accordingly.

A student who holds a graduate assistantship, fellowship, or traineeship may not accept employment, either at the University or elsewhere, during the period of his appointment, except when stipulated for training purposes in certain foundation and federal fellowship and traineeship programs.

The Office of Student Aid, 121 Grange Building, offers assistance to students in finding part-time employment in town as well as on the campus.

VETERANS' BENEFITS—The Coordinator of Veterans Affairs has the responsibility of handling all applications for benefits under the various Public Laws.

Under P. L. 89-358, a student is classified as full-time if he registers for 8 or more credits, or if he holds a half-time or quarter-time graduate assistantship.

Recently discharged servicemen not in this area may obtain information on veterans' educational benefits under P. L. 89-358 and its recent revision from the Veterans Administration representatives at their local county courthouses.

PROGRAMS AND COURSES

Programs of study leading to advanced degrees are offered in many major and minor fields. These are listed in the following section, and the major fields are summarized at the beginning of the following section. Related courses are grouped together under the name of the field. To locate a particular course or group of courses, consult the index.

In general, departments of the University are identified with specific major fields. Thus aerospace engineering is a major field of study which is offered under the supervision of the Department of Aerospace Engineering. On the other hand, engineering acoustics and comparative literature are major fields for which there are no corresponding departments. In such cases a committee of the Graduate School is responsible for administering the program. In some cases a single department offers work in more than one field. Thus the Department of Materials Science offers work in ceramic science, fuel science, metallurgy, and solid state science.

Applicants for admission are encouraged to consult the person whose name is listed under the major field heading.

DEGREES—In those major fields approved for the doctorate, the Ph.D. is normally conferred, although a program leading to the D.Ed. may also be arranged with the consent of the department or committee in charge if such a professional program is appropriate. Similarly, in major fields approved for the master's degree the M.A. or M.S. is normally conferred, but a program leading to the M.Adm., M.Agr., M.B.A., M.Ed., M.Eng., M.F.A., M.F., M.P.A., or M.R.P. may also be available. The D.Ed. and M.Ed. are not limited to the fields of education but, with the consent of the department or committee in charge, may be offered in any approved major field appropriate to the preparation of teachers, such as mathematics or English. In this case the program is sponsored by a major department outside the fields of education, such as the Department of Mathematics, but the student's minor is in education.

MINOR FIELDS—All major fields listed are also acceptable as minors, subject to the approval of the proposed minor department. In addition, a few fields in which

no advanced degrees are offered have been approved as minors for candidates who are majoring in related areas. Such minor fields are identified in the summary at the beginning of the following section and by a brief statement under the field heading in that section.

A candidate's choice of minor field depends upon the particular degree he is seeking and is subject to the approval of both his major and minor departments. The requirements in each minor field are established by the minor department subject to the regulations of the Graduate Faculty.

INTERDISCIPLINARY MAJORS—In addition to the majors listed on the following pages, interdisciplinary majors involving two or more departments may be arranged with the approval of the Dean of the Graduate School. These programs are offered under the supervision of appropriate interdepartmental committees.

OTHER FIELDS—Fields which have not been approved for either major or minor work, but in which approved courses are offered, are listed at the end of this bulletin. These courses may be used in graduate programs as electives or as part of a general studies program, subject to the approval of the major department and to the restrictions upon the use of 400-series courses in degree programs.

COURSE NUMBERING SYSTEM—Courses in the series 1-399 are not listed in this bulletin because they are strictly undergraduate and yield no graduate credit. A graduate student may register for or audit these courses in order to make up deficiencies or fill in gaps in his earlier education but not to meet requirements for an advanced degree.

Courses in the series 400-499 are for upperclassmen with at least junior standing and for graduate students. Only a limited number of credits earned in these courses may be counted toward the requirements for an advanced degree. Detailed regulations concerning the restrictions are given on pages 50-55 under the specific requirements for the various master's degrees.

Courses in the series 500-599 are restricted to students registered in the Graduate School, seniors with an average of at least 3.50, and other students who have been granted permission to enroll by the Dean of the Graduate School.

The numbers 601 and 611 do not denote courses but are used for noncredit registration by a Ph.D. candidate who is following the new regulations which went into effect in fall term 1967. Registration under these numbers will maintain his status as a student during the interval which begins at the time he has both passed the comprehensive examination and met the three-term, full-time academic requirement and ends at the time his doctoral committee accepts the thesis. The student will register for 601 if he will be using University facilities and/or faculty services; he will register for 611 if he will be off-campus and requiring little or no faculty service.

CREDITS—A credit is defined as a unit of time approximately equivalent to one week of full-time graduate study. Accordingly, a full-time student having no concurrent employment may earn a maximum of 10 credits in a ten-week term. A "credit" as used in this bulletin, therefore, is identical in meaning with a "semester credit" and should not be confused with a "quarter credit," which is associated with the traditional quarter system. By increasing the length of class periods to seventy-five minutes, the Penn State calendar based upon a ten-week term provides for the same amount of time in a given course as does the typical semester plan.

COURSE DESCRIPTIONS—A course abbreviation, a number, and a title designate each course. Course designations and official abbreviations are listed in the left-hand margin just above the first course in each group. The figures in parentheses following the course title show the number of credits which may be granted for that course. In the case of courses with variable credits, the number of credits which may be earned in a single term is determined by the department offering the course.

A department may schedule an entire section of a course below the 400 level for fewer credits than the maximum authorized. In 400- and 500-series courses a department may schedule an individual student for fewer credits than the maximum number but in no case for more than the maximum number authorized.

SCHEDULE OF COURSES—A complete list of the courses which will be offered in any specific term is given in the *Schedule of Classes,* which is available at nominal cost from the Scheduling Office approximately four months before the beginning of the term. It gives the number of credits being offered in each course, the hours at which the class will meet, the location of the class, and in some cases the instructor's name.

RESEARCH AND THESIS WORK—In registering for thesis work a student uses the appropriate number (600, 601, 610, or 611) preceded by the abbreviation designating his major field. Thus, ENGL 600 denotes thesis research in English being done on the University Park Campus and ENGL 610 thesis research in English being done off-campus.

The numbers 601 and 611 are available only to Ph.D. candidates who are following the new regulations, have passed the comprehensive examination, and have met the three-term, full-time academic requirement. Such a candidate in engineering mechanics will register for E MCH 601 if he will be using University facilities and/or faculty services or for E MCH 611 if he will be off-campus and requiring little or no faculty service.

It should be assumed that 600 and 610 are available in all graduate major fields and that 601 and 611 are available in all fields approved for the Ph.D., although these numbers may not always appear in the *Schedule of Classes* for each term.

Major and Minor Fields

GRADUATE FIELDS OF STUDY

Administration—M.Adm.
Aerospace Engineering—Ph.D., M.S.
Agricultural Economics—Ph.D., M.S., M.Agr.
Agricultural Education—Ph.D., D.Ed., M.S., M.Ed.
Agricultural Engineering—Ph.D., M.S.
Agronomy—Ph.D., M.S., M.Agr.
Anatomy—Ph.D., M.S.
Animal Industry—Ph.D., M.S., M.Agr.
Animal Nutrition—Ph.D., M.S.
Anthropology—Ph.D., M.A.
Architectural Engineering—M.S.
Architecture—M.S.
Art—M.A., M.F.A.
Art Education—Ph.D., D.Ed., M.S., M.Ed.
Art History—Ph.D., M.A.
Astronomy—Ph.D., M.S.
Biochemistry—Ph.D., M.S.
Biological Science—D.Ed., M.Ed.
Biophysics—Ph.D., M.S.
Botany—Ph.D., M.S.
Business Administration—Ph.D., M.S., M.B.A.
Business Education—Ph.D., D.Ed., M.S., M.Ed.
Ceramic Science—Ph.D., M.S.
Chemical Engineering—Ph.D., M.S.
Chemistry—Ph.D., M.S.
Child Development and Family Relationships—Ph.D., D.Ed., M.S., M.Ed.
Civil Engineering—Ph.D., M.S., M.Eng.
Classics—M.A.
Clothing and Textiles—Ph.D., D.Ed., M.S., M.Ed.
Comparative Literature—Ph.D., M.A.
Computer Science—Ph.D., M.S.
Counselor Education—Ph.D., D.Ed., M.S., M.Ed.
Dairy Science—Ph.D., M.S.
Earth Sciences—M.Ed.
Economics—Ph.D., M.A.
Education of Exceptional Children—Ph.D., D.Ed., M.S., M.Ed.
Educational Administration—Ph.D., D.Ed., M.S., M.Ed.
Educational Psychology—Ph.D., M.S.
Electrical Engineering—Ph.D., M.S., M.Eng.
Elementary Education—Ph.D., D.Ed., M.S., M.Ed.
Engineering Acoustics—Ph.D., M.S.
Engineering Mechanics—Ph.D., M.S., M.Eng.
Engineering Science—M.Eng.
English—Ph.D., D.Ed., M.A., M.Ed.
Entomology—Ph.D., M.S., M.Agr.
Extension Education—M.Agr., M.Ed.
Family Economics and Home Management—Ph.D., D.Ed., M.S., M.Ed.
Food Science—Ph.D., M.S.
Food Service and Housing Administration—M.S., M.Ed.
Foods and Nutrition—Ph.D., D.Ed., M.S., M.Ed.
Forest Resources—Ph.D., M.S., M.F.
French—Ph.D., M.A.
Fuel Science—Ph.D., M.S.
General Engineering—M.Ed., M.Eng.
General Family Studies—M.S., M.Ed.
Genetics—Ph.D., M.S.
Geochemistry—Ph.D., M.S.
Geography—Ph.D., D.Ed., M.S., M.Ed.
Geology—Ph.D., M.S.
Geophysics—Ph.D., M.S.
German—Ph.D., M.A., M.Ed.
Higher Education—D.Ed., M.Ed.
History—Ph.D., D.Ed., M.A., M.Ed.
Home Art (minor only)
Home Economics Education—Ph.D., D.Ed., M.S., M.Ed.
Horticulture—Ph.D., M.S., M.Agr.
Industrial Arts Education—Ph.D., D.Ed., M.S., M.Ed.
Industrial Engineering—Ph.D., M.S., M.Eng.
Journalism—M.A.
Laboratory Animal Medicine—M.S.
Mathematics—Ph.D., D.Ed., M.A., M.Ed.
Mechanical Engineering—Ph.D., M.S., M.Eng.
Metallurgy—Ph.D., M.S.
Meteorology—Ph.D., M.S.
Microbiology—Ph.D., M.S.
Mineral Economics—Ph.D., M.S.
Mineral Engineering Management—M.Eng.
Mineral Preparation—Ph.D., M.S.
Mineralogy and Petrology—Ph.D., M.S.
Mining Engineering—Ph.D., M.S.
Music—M.A., M.F.A.
Music Education—D.Ed., M.Ed.
Nuclear Engineering—Ph.D., M.S., M.Eng.
Nutrition in Public Health—M.S.
Petroleum and Natural Gas Engineering—Ph.D., M.S.
Philosophy—Ph.D., D.Ed., M.A., M.Ed.
Physical Education—Ph.D., D.Ed., M.S., M.Ed.
Physical Science—D.Ed., M.Ed.
Physics—Ph.D., D.Ed., M.S., M.Ed.
Physiology—Ph.D., M.S.
Plant Pathology—Ph.D., M.S.
Political Science—Ph.D., M.A.
Poultry Science—Ph.D., M.S.
Psychology—Ph.D., D.Ed., M.S.
Public Administration—M.P.A.
Recreation and Parks—M.S., M.Ed.
Regional Planning—M.R.P.
Rural Sociology—Ph.D., M.S., M.Agr.
Sanitary Engineering—M.S., M.Eng.
School Psychology—D.Ed., M.S., M.Ed.
Secondary Education—Ph.D., D.Ed., M.S., M.Ed.
Slavic Languages and Literatures—M.A.
Social Studies—M.Ed.
Sociology—Ph.D., M.A.
Solid State Science—Ph.D., M.S.
Spanish—Ph.D., D.Ed., M.A., M.Ed.
Speech—Ph.D., D.Ed., M.A., M.Ed.
Speech Pathology and Audiology—Ph.D., D.Ed., M.S., M.Ed.
Statistics—Ph.D., M.A., M.S.
Theatre Arts—M.A., M.F.A.
Vocational Industrial Education—Ph.D., D.Ed., M.S., M.Ed.
Wildlife Management—M.S.
Zoology—Ph.D., M.S.

The degrees listed above are the ones normally conferred in each of the designated major fields. Additional professional degrees, including the M.Agr., M.Ed., and M.Eng., have been authorized in many cases and may be offered at the discretion of the department head and the Dean of the Graduate School. Thus, the M.Ed. has been authorized for all of the above fields in which a master's degree is conferred provided the field is appropriate to the preparation of teachers.

COURSES IN MAJOR AND MINOR FIELDS

ADMINISTRATION (ADMIN)

ROBERT J. MCNEILL
In Charge of Graduate Programs in Administration at Capitol Campus
P. O. Box 230, Middletown, Pa. 17057

Degree Conferred: M.Adm.

This program is designed to meet the professional needs of practicing and potential administrators. A basic premise is that administration is a necessary function in all organizations and that it requires a common body of knowledge and skills regardless of its area of application. A total of 30 graduate credits is required—18 in the core courses and 12 in the area of specialization or option—with the majority of the courses at the 500 level. Four option areas are offered: business administration, engineering administration, public administration, and logistics administration. Each student is required to complete a research project in the field or in a laboratory in which he applies research methods and tests his solution through experimentation or simulation. The report must be of the quality, if not the theoretical depth, of a graduate thesis. After substantially completing the course requirements, a candidate must pass a comprehensive written and oral examination administered by a committee of graduate faculty members. The candidate will be expected to demonstrate his ability to integrate knowledge of a specialized area with a broad understanding of the general field of administration.

The program is offered only at the Capitol Campus.

AEROSPACE ENGINEERING (AERSP)

GEORGE F. WISLICENUS, *Head of the Department*
233 Hammond Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Holl, Lancaster, McCormick, and Wislicenus; Associate Professors Sevik and Tennekes.

Graduate Faculty, Associate Members: Assistant Professors Arndt and Lakshminarayana.

Opportunities are available for graduate study in the following and related areas: modern fluid mechanics and physics, the interaction of fluids with solids, and the application of these disciplines to the design of devices and to the environment in which they operate. These topics are specifically included: cavitation, magnetohydrodynamics, rarified gas dynamics, the stability of laminar motions, turbulence, aero- and hydroelasticity, stability and control of vehicles, turbomachinery, V/STOL aircraft, high lift devices, and ground effect machines.

The entering student must hold a bachelor's degree in physical science, mathematics, or engineering and may be required to complete (without degree credit) undergraduate course work in fluid and solid mechanics and intermediate mathematical analysis, if he has not already done so.

AEROSPACE ENGINEERING (AERSP)

401a,b,c. Aerospace Engineering Projects (1-12)
402. Aerospace Design (2)
407. Aerodynamics of V/STOL Aircraft (3)
410. Aircraft and Space Propulsion (3)
411. Aeroelasticity (3)
412. Turbulent Flow (3)
413. Stability and Control of Aircraft and Missiles (3)
415. Free Molecular Flow and Radiative Heat Transfer (3-6)
416-417. Aerospace Undergraduate Thesis (2 each)
420. Principles of Flight Testing (3)
421. (M.E. 421) Intermediate Viscous Flow (3)
422. (M.E. 422) Intermediate Inviscid Flow (3)
425. Theory of Flight (3)

503. Electromagnetically and Chemically Active Flows (3) Flow of media which may be conductive, permeable, ionizable, or otherwise capable of interacting with imposed or self-generated fields.

504. Aerodynamics of V/STOL Aircraft (3) Jet wings, high lift devices, propellers and ducted propellers, circulation and boundary layer control, unsteady airfoil theory. Prerequisite: Aersp. 407.

505. Aero- and Hydroelasticity (3) Interaction of elastic systems having several degrees of freedom with fluid flows in various configurations.

506. Cavitation (3) Flow regimes, dynamics of cavitation, prediction of the minimum pressure in the fluid, scale effects, effect of surface irregularities.

507. Theory and Design of Turbomachinery (3) Theory and principles of machinery design: compressors, turbines, pumps, and rotating propulsors; opportunity to work out design examples.

508. Perfect Fluid Theory A (3) Mathematical review, equations of motion and general consequences, application of complex variables to two-dimensional flow, conformal representations, Stokes' stream function.

509. Perfect Fluid Theory B (3) Review of axisymmetric motion; two-dimensional vortex motions; motions with cylindrical, spherical geometry; Bessel, Legendre functions; vortex motions in space. Prerequisite: Aersp. 508.

510. Compressible Flow (3) One-dimensional motion, shock waves, flow in nozzles, two-dimensional flow, airfoil theory. Prandtl-Meyer flow, method of characteristics.

512. Viscous Flow (3) Stress-deformation relations; Newtonian fluids, Navier-Stokes equations; exact, asymptotic laminar solutions; instability, transition; similitude and turbulent boundary layer.

514. Stability of Laminar Flows (3) The stability of laminar motions in various geometries as influenced by boundary conditions and body forces of various kinds.

515. Foundations of Turbulence (3) The mathematics underlying turbulence theory: descriptions, kinematics of stochastic fields; techniques of solution of linear and some nonlinear problems.

516. Homogeneous Turbulence (3) Dynamics: production, spectral transfer, dissipation, decay of energy; similarity theories.

517. Inhomogeneous Turbulence (3) Dynamics: similarity, structural hypotheses; spatial, spectral budget of energy in a number of classical flows.

518. Aircraft and Missile Dynamics (3) Dynamical problems of aircraft and missiles including launch, trajectory, optimization, orbiting, re-entry, stability and control, and automatic control. Prerequisite: Aersp. 413.

520. Selected Topics in Aerospace Engineering (1-12)

AGRICULTURAL ECONOMICS (AG EC)

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
6-A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Barr, Becker, Bennett, Brandow, Butz, Frey, Hutton, McAlexander, Pasto, Pierce, Stemberger, and Trotter; Associate Professor Partenheimer.

Graduate Faculty, Associate Members: Assistant Professors Gamble, Hallberg, Herrmann, Holt, Jansma, and Schutjer.

The graduate program emphasizes economic theory and analytical techniques in conjunction with concentration in farm management, production economics, agricultural marketing, resource economics, agricultural policy and prices, or international agricultural trade and development.

The entering student in the master's program should have as prerequisites 3 credits in agricultural economics, 3 credits in economics, and 3 additional credits in either agricultural economics or economics. If a student lacks some of the prerequisites, he may take them without graduate credit during the early part of his master's program.

AGRICULTURAL ECONOMICS (AG EC)

407. Advanced Farm Management (3)
410. Agricultural Finance and Appraisal (3)
420. Agricultural Prices (3) *Mr. Bennett*
421. Land Economics (3) *Messrs. Frey and Gamble*
422. Land and Water Resource Policy (3) *Mr. Jansma*
450. International Agricultural Trade and Development (3) *Mr. Schutjer*
460. Industrial Organization in Food Processing and Distribution (3) *Mr. Brandow*
461. Decision-Making in Agricultural Marketing Firms (3) *Mr. Stemberger*

500. Seminar in Agricultural Economics (1-6) Review of current literature and problems.

504. Seminar in Agricultural Policy (3) Analysis of farm prices, income consequences for producers and consumers, and effects on resource use; evaluation of policy, considerations in policy-making. Prerequisites: Ag.Ec. 420, Econ. 405. Odd years. *Mr. Brandow*

505. Advanced Agricultural Statistics (3) Multiple correlation, curve fitting, analysis of variance, and other techniques applicable to the rural social sciences. Prerequisite: 3 credits in statistics. *Mr. Bennett*

507. Seminar in Farm Management (1-6) Special problems relating to organization and operation of the farm business. Prerequisites: Ag.Ec. 6, Econ. 14.

514. Survey Research Techniques in Agricultural Economics (3) Survey methods and design of samples for obtaining economic data from business-unit and household populations. Prerequisite: Ag. 400. Odd years.

515. Economic Problems in the Marketing of Dairy Products (3) Economic problems as they are encountered in the process of marketing; particular attention to governmental regulation in pricing and marketing. *Mr. Pierce*

520. Farm Price Analysis (3) Econometric analysis of prices, production, and utilization of farm products; review of research in this field. Prerequisites: Ag.Ec. 420, 505; Econ. 405. Even years. *Mr. Hallberg*

525. Research Methods in Rural Social Sciences (2) Scientific method in planning and conducting research. Prerequisite: 9 credits in social sciences. *Mr. John*

527. Seminar in Applied Quantitative Methods (1-4)

534. Agricultural Production Economics (3) Economic theory applied to agricultural production problems: resource combinations, firm size, uncertainty and expectations, aggregate aspects of production, technological change.

535. Seminar in Agricultural Marketing (2)

541. Economic Organization of Agriculture (3) Agriculture as a sector of the total economy; changes in markets, resources, internal structure, and income; interregional competition.

550. Food Consumption Economics (3) Demand theory and research methods applied to the market for foods. *Mr. Herrmann*

571. Seminar in Land and Water Resource Economics (3) Critical review of research in resource economics; consideration of special topics in resource use. *Mr. Jansma*

AGRICULTURAL EDUCATION (AG ED)

David R. McClay, *Head of the Department*
101 Agricultural Education Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors McClay and Stevens, Associate Professor Stinson.

Graduate Faculty, Associate Members: Associate Professors Anthony and Hoover.

Graduate programs emphasize the professional improvement of teachers. They provide advanced preparation for employment in administration, supervision, teacher education, and research in agricultural education and related fields. A minor may be taken in an area of agricultural science, technology, business, or in general studies. Programs may include courses needed for certification in other fields of education.

AGRICULTURAL EDUCATION (AG ED)

400v. Educational Programs in Agriculture for Developing Countries (3)
418v. Survey of Vocational Education in Agriculture (1-4)
420v. Instructional Media in Agriculture (1-6)
422v. Supervision of Vocational Education in Agriculture (1-4)
424v. Occupational Guidance in Agricultural Industry (1-4)
426v. Adult Education in Agriculture (1-4)
434v. Agricultural Developments (1-6)

501v. Agricultural Education in the United States (1-3) Historical development, social and philosophical foundations, and current status in relation to the total vocational-technical education program.

502v. Teaching Agriculture (1-3) Vocational education objectives, learning theory, class instruction, cooperative occupational experience, and evaluation.

503v. Research in Agricultural Education (1-6 per term) Individual study problems in various phases of agricultural education, such as evaluation of teaching, teaching procedures, and teacher preparation.

504v. Agricultural Education Seminar (1 per term)

508v. Administration and Supervision of Agricultural Education (1-3) Administration of state and district systems of vocational-technical education; supervision of teachers of agriculture.

509v. Teacher Education in Agriculture (1-6) Organization and administration of university programs of teacher education in agriculture, including pre-service preparation, continuing education, research, and other services.

520v. Scientific Method in the Study of Agricultural Education (1-4) Methods of procedure in investigation and experimentation in education, accompanied by a critical examination of studies made in agricultural education.

521v. Scientific Method in the Study of Agricultural Education (1-4) Continuation of Ag.Ed. 520v; emphasis upon statistical techniques for students' individual problems.

524v. Program Development in Agricultural Education (1-3) Analysis of occupational needs of students and employment prospects; organization of courses of study and other activities of teachers.

530. Agricultural College Teaching (3) Selection and organization of subject matter for specific courses, methods of learning, teaching devices, technique of teaching, and measurements of results of teaching.

AGRICULTURAL ENGINEERING (AG E)

Frank W. Peikert, *Head of the Department*
250 Agricultural Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Mohsenin and Peikert.
Graduate Faculty, Associate Members: Professors Aldrich, Bartlett, Schroeder, and Stephenson; Associate Professor Kjelgaard.

AGRICULTURAL ENGINEERING

Graduate programs are available in the areas of physical properties of agricultural materials; plant and animal environmental engineering; agricultural processing and food engineering; agricultural mechanization with emphasis on forage, fruits, and vegetables; rural sanitation and conservation engineering; and computer technology applied to agricultural engineering problems.

Excellent facilities, including equipment and instrumentation, are available for research in the designated areas. Among the special facilities are freeze-drying equipment for drying by sublimation, solar poultry houses and plant growth structures for modified atmosphere, a general purpose analog computer, and a laboratory for research on mechanical and rheological properties of agricultural materials. This laboratory is equipped with an Instron testing machine, complete with environmental chamber for research on the rheology of foods and agricultural materials. It also contains a polaroscope and acoustical instrumentation with which mechanical properties of agricultural materials can be studied using photoelastic stress analysis and sonic techniques.

Prerequisite to major work is the completion of an undergraduate major in engineering.

AGRICULTURAL ENGINEERING (AG E)

400. Agricultural Engineering Problems (1-7)
401. Farm Mechanics for Teachers of Vocational Agriculture (1½-9)
402. Functional Design of Agricultural Structures (3)
404. Agricultural Machinery (3)
405. Agricultural Process Engineering (3)
406. Advanced Dairy Engineering (3)
407. Soil Water Engineering (3)
408. Instrumentation for Agricultural Production and Processing (3)
409. Agricultural Systems Engineering (3)
410. Agricultural Power (3)
420. Seminar (1)

500. Advanced Electro-Agriculture (1-6) Investigations in the application of electrical energy to processing, storing, and handling agricultural products. Seminar, written reports.

501. Advanced Farm Machinery (1-6) Application of agricultural engineering principles to design and operation of farm machinery. Prerequisite: Ag.E. 410.

502. Farm Structures Problems (1-6) Analysis of farm structures design problems.

503. Physical Properties of Plant and Animal Products (3) Physical characteristics; mechanical, rheological, thermal, electrical, and optical properties in relation to handling, storage, processing, and quality evaluation.

505. Experimental and Applied Instrumentation (4) The theory and application of electronics for instrumentation and experimental research.

507. Problems in Soil Water Engineering (1-6) Analysis of engineering problems relating to irrigation, drainage, or erosion control.

508. Advanced Problems in Farm Mechanics (1-15) Problems in farm shop practice and agricultural engineering related to the farm mechanics program of vocational education in agriculture. Prerequisites: Ag.E. 8, 14; or teaching experience in farm mechanics.

509. Research in Agricultural Engineering (1-4)

520. Agricultural Engineering Seminar (1-3) Reports on research and special topics.

AGRONOMY (AGRO)

Walter I. Thomas, *Head of the Department*
118 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Duich, Fortmann, Hunter, Kardos, Matelski, Richer, Robinson, Thomas, and Washko; Associate Professors Baker, Cleveland, McKee, and Starling.

Graduate Faculty, Associate Members: Professor Raleigh; Associate Professors Cunningham, Harrington, L. J. Johnson, M. W. Johnson, Marriott, Marshall, Pfeifer, and Waddington; Assistant Professors Bollag, Hall, and Hill.

Areas of specialization include soil chemistry; soil conservation; soil classification; soil fertility; soil mineralogy; soil physics; the genetics and breeding of corn, small grains, and forage plants; forage management; turf management; potato culture; tobacco culture; weed control; and ecology of crops and pastures.

Prerequisites for major work in agronomy vary with the area of specialization, but basic courses in chemistry, mathematics, physics, and biological sciences are required. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

AGRONOMY (AGRO)

411. Breeding of Field Crops (3) — *Mr. Johnson*
415. Soil Morphology, Mapping, and Classification (3) — *Mr. Petersen*
416. Soil Genesis (3) — *Mr. Petersen*
417. Forest Soils (3) — *Mr. Ciolkosz*
419. Soil Properties (4) — *Mr. Baker*
422. Soil Conservation (3) — *Mr. Cunningham*
423. Pasture and Grassland Management (3) — *Mr. Washko*
424. Fertilizer Technology (3) — *Mr. Marriott*
425. Principles of Field Crop Production (3) — *Mr. Pfeifer*
431. Soil Fertility and Management (3) — *Mr. Marriott*
438. Principles of Weed Control (3) — *Mr. Raleigh*
490. Agronomic Problems (1-6) — *Mr. Washko and Staff*

501. Advanced Soil Fertility (4) Interpretation of fertility experiments and diagnosis of soil-plant relationships through field appraisal, analysis, and plant symptoms. Prerequisites: Agro. 431, Biol. 441. *Mr. Hunter*

503. Agronomy Seminar (1) Weekly meeting where papers and discussions will be presented by students and staff members.

506. Soil Chemistry (4) Analyses of important chemical and biochemical reactions occurring in soils, conditions which control these reactions and their importance in soil genesis and plant growth; laboratory work in the more typical and significant analytical procedures; lectures, review of current literature, and practicum. Prerequisites: Agro. 419; Bioch. 425 or Chem. 451. *Mr. Baker*

507. Soil Physics (4) Physical properties of the soil; factors affecting them; their measurements, evaluation, and influence in determination of soil productivity. Prerequisites: Agro. 419, Bioch. 425, Phys. 215. *Mr. Kardos*

509. Genetics of Crop Plants (3) Inheritance in crop plants with particular reference to factor interaction, genetic aspects of linkage and crossing-over, quantitative inheritance, and heterosis. Prerequisite: Biol. 422. *Mr. Cleveland*

510. The Application of Cytogenetics to Plant Breeding (3) Cytogenetics, including chromosome structure and behavior, chromosome alterations, polyploidy, interspecific hybridization, and their applications to plant breeding. Prerequisite: Biol. 422. *Mr. Cleveland*

512. Field Plot Technique (4) Ramifications of analysis of variance techniques; combining and analyzing data from several experiments; selection of valid error terms. Prerequisite: Stat. 200 or Ag. 400. *Mr. Starling*

516. Humus (2) Origin and chemical nature of soil organic matter, its importance in soil processes, and its decomposition. Prerequisites: Agro. 419, 431. *Mr. Richer*

517. Farm Crops Ecology (3) Ecological factors affecting growth and development of farm crops with particular reference to effects of altered environment and management practices. Prerequisites: Agro. 28, Biol. 441. *Mr. McKee*

518. Growth and Management of Forage Crops (3) Factors affecting growth and development of forage crops with particular reference to effects of environment, defoliation, and management practices. Prerequisites: Agro. 423, Biol. 441. *Mr. McKee*

519. The Nature of Soil Minerals (3) Modern methods for identification of the constituent minerals of soils and their relation to soil classification and agricultural practices. Prerequisites: Agro. 419, G.Sc. 23. *Mr. Johnson*

545. The Application of Statistics to Field Experiments (4) Use of advanced experimental designs in planning, analyzing, and interpreting experiments; includes lattice designs, factorials, confounding, simple and multiple covariance techniques. Prerequisite: Agro. 512. *Mr. Starling*

*550. Agronomic Problems (1-12) Provides training in selected areas of agronomy by means of supervised investigations or studies.

582. Seminar in the Breeding and Genetics of Farm Crops (1 per term)

ANATOMY (ANAT)

Bryce L. Munger, *Chairman of the Department*
The Milton S. Hershey Medical Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Associate Professors Baird and Ha, Assistant Professor Pubols.
Graduate Faculty, Associate Member: Mrs. Pubols.

The graduate program emphasizes the general areas of gross anatomy, histology/

* Credits 1-6 per term.

cytology, neuroanatomy/neurophysiology, or appropriate combinations of these areas. Approaches offered include morphological (descriptive, comparative, developmental), functional (physiological, chemical), and experimental. A bachelor's degree reflecting a reasonable background in zoology or biology, mathematics, and chemistry is required; reading knowledge of one or two foreign languages is recommended. Applicants must provide complete transcripts and two letters of recommendation, and scores from the Graduate Record Examination. A personal interview is desirable.

This program is offered only at the Milton S. Hershey Medical Center. For course listings at the Center see pages 245 to 248.

ANIMAL INDUSTRY (A I)

THOMAS B. KING
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professor Bortree, Associate Professors Gobble and Sink.

Graduate Faculty, Associate Members: Professor King; Associate Professors Sherritt, Wilson, and Ziegler.

A student may specialize in animal production and management, animal breeding, or meats. For admission the student must complete an undergraduate major in animal science or a closely related field. Students who lack some of the course prerequisites may be admitted but are required to take the prerequisite courses without degree credit.

ANIMAL INDUSTRY (A I)

400. SPECIAL TOPICS (1-6)
405. MEAT ANIMAL MANAGEMENT (4)
421. SCIENCE OF MEAT (3)
423. ADVANCED LIVESTOCK SELECTION (2)
424. ANIMAL INDUSTRY SEMINAR (1)
431. ADVANCED MEAT SELECTION AND GRADING (2)

500. SEMINAR IN ANIMAL INDUSTRY (1-6)

501. PEDIGREE STUDY (1-6) Research work in breed study history, and analytical study of breed pedigrees, and a complete survey of the herd, flock, or stud book.

502. RESEARCH IN MEATS (1-6 per term) Investigation of methods for handling, cutting, processing, freezing, and curing meat and meat products. Prerequisite: A.I. 421.

503. PROBLEMS IN THE ANIMAL INDUSTRY (1-6) Literature review, research methods, and current research in problems relating to the animal industry.

505. Advanced Animal Breeding (1-5) Special problems in animal genetics as applied to breeding and improvement of horses, cattle, sheep, and swine. Prerequisite: An.Sc. 322.

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses." Also see Food Science.*

ANIMAL NUTRITION (A NTR)

Thomas B. King
Head of the Department of Animal Science
202 Armsby Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Barron, Baumgardt, Bratzler, and Hartsook; Associate Professor Hershberger.
Graduate Faculty, Associate Members: Professors Cowan and King; Associate Professor Long.

The graduate program emphasizes nutrition, including energy metabolism, physiology of nutrition, and growth. For admission without deficiencies an applicant should have had at least one year's work each in general chemistry, organic chemistry, and physics; 3 credits in analytical chemistry; 3 credits in biochemistry; mathematics through integral calculus; and 9 credits in biology.

ANIMAL NUTRITION (A NTR)

401. Physiology of Nutrition (3)
402. Energy and Protein Metabolism (3)

505. Ruminology (3) Physiological, biochemical, and microbiological activities occurring within the rumen and the relation of rumen function to animal response. Prerequisites: at least one course in each of the following areas: animal nutrition, physiology, microbiology, and biochemistry.

Note: *See Animal Science listing under "Other Elective Graduate Courses."*

ANTHROPOLOGY (ANTHY)

Paul T. Baker
Acting Head of the Department
Walnut Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Baker, Carpenter, Matson, Mook, and Sanders.
Graduate Faculty, Associate Members: Assistant Professors Nydegger and Escobar.

The master's program is designed to train students in general anthropology. The doctoral program is structured to train students in the following areas of specialization: new world archaeology, middle eastern archaeology, archaeological methodology, physical anthropology with special emphasis on human ecology, cultural ecology, comparative economics, personality and culture, oceanic ethnology, Latin American ethnology, folk and peasant society.

Undergraduate preparation must include 12 credits in anthropology and archaeology or their equivalent and at least 6 credits in related sciences. A student with an excellent record but who does not meet these requirements may be admitted provided he makes up course deficiencies without graduate credit.

A thesis is required of all M.A. candidates in this field.

The M.A. degree may be bypassed by exceptional candidates for the Ph.D. degree.

ANTHROPOLOGY (ANTHY)

400. Human Evolution: the Material Evidence (3)
401. Human Evolution: Theory and Process (3)
402. Human Ecology (3)
403. Applied Physical Anthropology (3)
405. Primatology (3)
420. Archaeology of the Near East (3)
422. Archaeology of Meso-America (3)
423. Archaeology of Eastern United States (3)
440. Ethnology of South America (3)
443. Ethnology of the Old World (3-6)
444. Ethnology of Meso-America (3)
446. Ethnology of North America (3)
447. Ethnology of Sub-Saharan Africa (3)
449. Ethnology of Southeast Asia (3)
450. Comparative Social Organization (3)
451. Economic Anthropology (3)
453. (Soc. 453) Primitive Religion (3)
455. Culture and Personality (3)
456. Cultural Ecology (3)
457. Language in Culture (3)
460. Anthropological Theory (3)
461. Methods in Cultural Anthropology (3)
462. Methods in Archaeology (3)
463. Field Linguistics (3)

501. Evolution of Human Behavior (3) The application of evolutionary theory to the study of man's structure, function, and culture. Prerequisites: Anthy. 21 or 401, and 3 additional credits in anthropology, sociology, or psychology.

502-503. Ecological Theory in Anthropology (3 each) Man's biology, culture history, and culture variation from the ecological perspective. Two-term enrollment required. Prerequisite: 6 credits in anthropology.

504. Applied Anthropology (3) Methods and results of studies in which anthropological theory was applied to current problems in human biology and culture.

505. Naturalistic Behavior of Nonhuman Primates (3) Comparative study of behavior including taxonomy, geographic distribution, ecology, territoriality, population composition, grouping patterns, individual and group interactional characteristics, communication.

506. Cultural Dynamics (3) Survey of the major theories of culture change with special reference to archaeological research.

507. The Biology of Human Adaptability (3) An exploration of the biological mechanisms which aid man's survival in a variety of environmental settings.

508. Research Problems in Culture History (3)

509. Seminar in Regional Studies (3-6) Research and analysis in selected world cultural areas, including ecology, pre-history, history, ethnography, and current status.

530. Individual Readings in Anthropology (1-6) Reading or research in selected aspects of general anthropology.

531. Individual Research in Anthropology (3-6)

545. Seminar in Anthropology (1-9) Critical analysis of research in selected areas of anthropology.

560. Anthropological Theory (3) Theory used in culture-historical, sociological, and psychological interpretations.

561. Field Methods in Anthropology (3-9) Individual field work in any aspect of anthropology, supervised by staff of professorial rank.

562. Laboratory Methods in Anthropology (3-9) Supervised laboratory research, utilizing materials from physical anthropology or archaeology or cultural anthropology.

563. Seminar in Linguistic Anthropology (3-6) Organized research on special topics in linguistic anthropology.

ARCHITECTURAL ENGINEERING (A E)

Gifford H. Albright, *Head of the Department*
101 Engineering A Building

Degree Conferred: M.S.

Graduate Faculty, Senior Member: Professor Richardson.
Graduate Faculty, Associate Member: Associate Professor Albright.

Students may specialize in structural analysis and design, environmental control engineering, illumination, acoustics, materials of construction, computer application to building design and performance, or nuclear defensive and protective construction. The latter area includes shelter planning, effects of nuclear weapons, shelter environmental requirements, analysis and design of blast-resistant structural systems, and integrated engineering requirements for protective construction.

For admission a student must have a strong background in some field of engineering; in engineering science or mechanics; or in architecture, psychology, economics, or management if there is adequate preparation in the physical sciences and mathematics. The detailed requirements depend upon the student's area of special interest.

ARCHITECTURAL ENGINEERING (A E)

401. Architectural Engineering (3)
402. Architectural Engineering (3)
403. Architectural Engineering (3)

430. Architectural Engineering (3)
431. Architectural Engineering (3)
439. Architectural Engineering (3)
441. Integration of Architectural Engineering Systems (3)
442. Research in Architectural Engineering (1-6)
454. Environmental Engineering in Buildings—Design (3)
458. Advanced Architectural Acoustics and Noise Control (3)
464. Advanced Architectural Illumination Systems Design (3)
481. Architectural Engineering Thesis (2)
482. Architectural Engineering Thesis (2)
483. Architectural Engineering Thesis (2)
486. Professional Engineering Practice (3)

502. Architectural Engineering (3-8) Advanced structural design in steel and reinforced concrete. Lectures and class criticism. Practicum and seminar.
Mr. Richardson and Staff

503. Architectural Engineering (4-8) Continuation of A.E. 502 in which problems of wind bracing in tall buildings, rigid frames, and heavy-framed constructions are studied. Practicum and seminar. *Mr. Richardson and Staff*

542. Advanced Problems and Research in Architectural Engineering (2-12) Investigation, analysis, and preparation of comprehensive report on subject relating to special problems in architectural engineering systems.

545. Architectural Engineering Seminar (1-6) Current literature and special problems in architectural engineering; presentation of technical papers.

551. Advanced Nuclear Defense Planning and Design I (3) Weapons effects data; dynamic strength of materials and structural elements; dynamic design; architectural, structural, electrical, and mechanical requirements for shelters. Prerequisites: A.E. 4, 5; E.Mch. 12.

552. Advanced Nuclear Defense Planning and Design II (3) Blast-resistant design of framed structures, shear wall structures, arches, domes, and underground structures; radiation shielding characteristics of building materials. Prerequisites: A.E. 431, 432, 551; Phys. 237.

553. Selected Problems in Nuclear Defense Research (1-6)

ARCHITECTURE (ARCH)

Raniero Corbelletti, *Head of the Department*
308 Sackett Building

Degree Conferred: M.S.

Graduate Faculty, Senior Member: Professor Corbelletti.
Graduate Faculty, Associate Member: Professor Hallock.

Advanced studies are offered in architecture, urban design, and planning. The student is offered opportunity for independent research and extensive interdisciplinary work under the guidance of specialists and scholars in technical, cultural, industrial, and social fields.

For admission, a five-year bachelor's degree program in architecture is required.

ARCHITECTURE (ARCH)

415. City Planning (3)
416. City Planning (3)
443. Architectural Design Analysis (3)

501. Architectural Design (4-8) Problems in advanced planning and design, including study of group composition. Practicum and seminar.

502. Architectural Research (2-12) Prosecution of assigned problems under the guidance of an instructor.

ART (ART)

Wirth V. McCoy, *Head of the Department*
210 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Associate Members: Professors Altman, Fraenkel, McCoy, and Zoretich; Associate Professors Adams, Cook, Frost, Montenegro, and Shobaken.

The M.A. program is planned to provide a broad range of experience and study in the visual arts. A thesis in an area of specialization is required. Requirements for admission include a broad undergraduate training in art and the presentation of a portfolio or examples of the student's work.

The M.F.A. program is planned to provide professional emphasis in a specific area of art. A creative project and supporting monograph are required. Requirements for admission include 24 credits in studio art with some indication of concentration in a chosen area and a statement of purpose concerning the professional aims of the candidate. A portfolio, photographs, or examples of the student's work must be presented.

All students accepted for graduate study in art who lack the adequate undergraduate courses or show deficiencies in some area will be required to take additional course work without degree credit.

ART (ART)

411. Seminar in Art (3)
412. Individual Instruction (3)
*425. Advanced Drawing (3)
*430. Advanced Sculpture (3)
*448. Advanced Printmaking (3)
*450. Advanced Painting (3)
*460. Advanced Watercolor (3)
470. Graphic Design II (3)
471. Graphic Design III (3)
472. Exhibition Concepts and Structure (3)
473. Seminar in Design Research (3)
*480. Advanced Ceramics (3)
495. Advanced Photography (3)

* May be repeated for a total of 12 credits.

501. Art Research (2-6) Original study and practice in art relating to material, concept, or technique.

530. Advanced Sculpture (3-12) Individual projects in sculpture leading to the development of a collection or body of work representative of the artist.

545. Printmaking (2-12) Problems in printmaking leading to the development of a collection or body of work representative of the individual artist.

550. Painting (2-12) Individual problems in painting leading to the development of a collection or body of work representative of the artist.

570. Design (2-12) Individual projects in design with special emphasis on professional practice in specialized fields of graphic design.

580. Ceramics (2-12) Experimental problems in ceramics leading to the development of a collection or body of work representative of the individual.

ART EDUCATION (A ED)

Edward L. Mattil, *Head of the Department*
269 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Beittel, Chomicky, and Mattil; Associate Professor Edmonston.

Graduate Faculty, Associate Members: Associate Professors Schwartz and Stewart.

Graduate programs in this field prepare students for careers in public school art teaching, art supervision, college teaching, or research. To be admitted without deficiencies, the student is expected to have completed either a baccalaureate program in art education or a program leading to certification. Such a program would include work in art studio, art history, art education, education, and psychology. Deficiencies may be made up by course work which is not counted as credit toward an advanced degree.

All students are expected to complete two years of teaching before receiving the doctor's degree.

ART EDUCATION (A ED)

404. Methods of Graphics and Illustrations (3)
414. Advanced Crafts for Teachers (3-6)
420. Ceramics for Teachers (3)
434. Art Appreciation in the Educational Program (3)
435. Art in the Elementary School (3)
436. Art in the Secondary School (3)
486. Current Problems in Art Education (2-3)
487. Mural Painting in Schools (3)
488. Advanced Mural Painting in Schools (3)
489. Art Experiences with Children (3)
498. Introduction to Research in Art Education (3)

501. Seminar in Art Education (1-6) The analysis of fundamental concept derived from related disciplines; the examination of current problems; current lit erature.

504. Advanced Methods in Graphic Processes (3) Exploration through labora tory experience of printing method: etching, silk screen, linoleum, or other; ap plications in teaching.

514. Functional Relationships in Crafts (3) Relationships of material desig and purpose in crafts discussed by means of outstanding products of differen materials, periods, and cultures. Prerequisite: 6 credits in crafts or 3 in design an 3 in advanced crafts.

516. Analysis of Three-Dimensional Processes in Art (3) Three-dimensiona processes analyzed with regard to kinetic, textural, form, and other functions.

520. Advanced Ceramic Art (3) Intensified exploration of throwing, glazing and firing processes as related to aesthetic considerations in contemporary art form and past cultures. Prerequisite: A.Ed. 420.

534. Creative Art Activity for the Handicapped (3) Specific methods for de velopment of creative art activity with the physically, mentally, emotionally, an socially handicapped; adjustive effect upon them. Prerequisite: 6 credits in ar education or 6 in special education or 6 in psychology.

535. Administration and Supervision of Art Education Programs (3) Th problems and responsibilities of the city, county, and state art supervisor; curricu lum, facilities, financing, supervision, in-service training, and reporting. Prerequi sites: A.Ed. 435, 436.

536. Curriculum Development in Art Education (3) Factors affecting ar curriculum decisions, analysis, selection, organization, preparation of curriculum Evaluation and sources of art curriculum improvement and innovation. Prerequi site: 6 credits of methods.

588. History of Art Education (3) Historical development of philosophies i art education in the United States and abroad.

597. Research in Art Education (1-6) Independent research, under an adviser to be terminated by a scholarly report proportionately comparable in quality to master's thesis. Prerequisite: 15 credits in art education on the 400 and 500 levels including A.Ed. 598.

598. Research Methods in Art Education (3-6) Orientation in research meth ods; findings and designs related to the study of problems in art education.

ART HISTORY (ART H)

Winston R. Weisman, *Head of the Department*
229 Arts Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Battisti, Enggass, Hyslop, and Weis man.

Graduate Faculty, Associate Member: Associate Professor Mauner.

Graduate work is offered in the following areas: modern, Renaissance and Baroque, medieval, ancient. Special research opportunities are available through the Center for the Study of Renaissance and Baroque Art.

For admission a minimum of 18 credits in art history is required. Lacking these, a promising candidate may be accepted on condition that he make up the deficiency without graduate degree credit. Candidates for the M.A. are required to complete a master's thesis and to demonstrate a reading knowledge of at least one foreign language. Candidates for the Ph.D. degree must pass a written comprehensive examination upon completion of their course work and, usually, before beginning the dissertation. They must also demonstrate a reading knowledge of two foreign languages. The department normally requires that the student take German and either French or Italian. Other languages may be substituted with the approval of the adviser.

ART HISTORY (ART H)

400. Studies in Art History (3-6 per term)
401. Studies in Greek Art (3)
402. The Illuminated Manuscript (3)
405. Pioneers of Modern Architecture (3-6)
410. Taste and Criticism in Art (3)
411. Art of Imperial Rome (3)
412. The Gothic Cathedral (3)
414. Studies in Italian Baroque Art (3-9)
415. The Skyscraper (3)
416. American Painting: 1876-1913 (3)
422. Studies in Medieval Sculpture (3)
423. Studies in Italian Renaissance Art (3-9)
424. Masters of Northern Baroque Art (3)
425. Movements in 19th Century Art (3)
435. Movements in 20th Century Art (3-6)

500. Methods of Research (3-6) Methods of art-historical research with emphasis on bibliographic and photographic resources.

510. Art History Research (3-6 per term) Original investigation in art history, to be pursued independently or concurrently with course work in particular fields.

511. Seminar in Ancient Art (3-12) Selected topics from the history of Greek and Roman art.

512. Seminar in Medieval Art (3-12) Original research into problems dealing with the art of the Middle Ages.

513. Seminar in Renaissance Art (3-12) Investigations in the area of Renaissance art, centering around major masters and monuments.

514. Seminar in Baroque Art (3-12) Investigations in the area of Baroque art centering around major masters and monuments.

515. Seminar in Modern Art (3-12) Lectures, readings, reports, and discussions in the field of modern art.

517. Seminar in Eighteenth Century Art (3-12) Investigation into themes and problems dealing with eighteenth century art.

525. Seminar in Modern Architecture (3-12) Investigation into the works and problems of modern architecture as they relate to the culture of our times.

ASTRONOMY (ASTRO)

JOHN P. HAGEN, *Head of the Department*
103 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Hagen and Matsushima, Associate Professors Mjolsness and Sampson.

Graduate Faculty, Associate Members: Associate Professors Bauer and Zabriskie; Assistant Professor Winkler.

Opportunities are available to prepare for research or teaching. The principal research facilities of the department are in radio astronomy, but work can be done in meteors, astrophysics, and in various phases of theoretical astronomy. Modern astronomy has very close ties with mathematics, physics, and engineering. The program required of a doctoral candidate would normally include courses in at least two of these related fields, in addition to those in astronomy.

A bachelor's degree in astronomy, physics, mathematics, or related branches of engineering is required for admission. Opportunity to make up possible undergraduate deficiencies is provided.

ASTRONOMY (ASTRO)

430. GENERAL ASTRONOMY FOR TEACHERS (3)
470. SOLAR PHYSICS (3)
490-491. INTRODUCTION TO ASTROPHYSICS (3 each)
492. SPACE ASTRONOMY (3)
495. PRACTICAL ASTRONOMY (3)

510. ASTROPHYSICS (3) An introduction to astrophysics in which the relevant physics, spectra, gas laws, plasmas, and radiation transfer theory are discussed.

511. ASTROPHYSICS (3) Stellar atmospheres; considerable emphasis is placed on the sun and on solar-terrestrial relationships. Prerequisite: Astro. 510.

512. ASTROPHYSICS (3) Stellar interiors, stellar evolution, pulsating stars, novae and supernovae; some discussions of the interstellar medium and gaseous nebulae. Prerequisite: Astro. 510.

513. OBSERVATIONAL TECHNIQUES IN ASTRONOMY (3) Radiation quantities in theory and as observed. Astrometry, photometry, spectroscopy, stellar classification, interferometric methods. Observational laboratory. Prerequisite: Astro. 511.

516. NON-EQUILIBRIUM RADIATIVE TRANSFER THEORY (3) Detailed study of theory of radiative transfer when the assumption of local thermodynamic equilibrium is not made, with astrophysical applications. Prerequisite: Astro. 511 or Phys. 561.

520. GALACTIC STRUCTURE (3) Stellar clusters and associations, galactic dynamics, stellar populations, distance determinations, luminosity calibration, and stellar statistics.

522. SPHERICAL ASTRONOMY (3) Astronomical coordinate systems, Kepler's equation, aberration, parallax, precession and nutation, time, eclipses and occultations, and solar motion.

523. OBSERVATIONAL THEORY (3) Information theory of noisy signals, statistics of

nonlinear functions, theory and application of convolutions, selection effects, systematic errors, selected problems. Prerequisite: Astro. 513.

525. Double Stars (3) Two-body theory; analysis of visual, astrometric, spectroscopic, and eclipsing binaries; and discussions of particular systems. Prerequisite: Astro. 522.

530. Theory of Stellar Atmospheres (3) Theory of photospheric structure, radiative processes, and line-formation in the outer layers of stars, and interpretation of stellar spectra. Prerequisite: Astro. 511.

534. Stellar Structure and Evolution (3) A detailed study of the theory of the interiors and evolution of stars. Prerequisite: Astro. 511 or Phys. 561.

542. Gaseous Nebulae and Interstellar Matter (3) Theory and observations of galactic nebulae and interstellar medium, and problems related to the formation of stars and galactic structure. Prerequisite: Astro. 511.

560-561. General Relativity and Cosmological Models (3 each) Riemannian geometry; general relativity theory and experiments; massive bodies; and Newtonian, Einsteinian, and steady state cosmologies are studied. Prerequisite: Phys. 525.

582. Radio Astronomy (3) Radiometers and antennas; signals in noise; solar physics; quiet and active solar radiation; transfer equation and solar radiation; solar-terrestrial effects. Prerequisite: E.E. 438 or Phys. 467.

583. Radio Astronomy (3) Radio astronomical studies of the moon and planets, galactic and extragalactic sources, and the structure of galaxies using line spectra. Prerequisite: Astro. 582.

590. Special Topics (1-3 per term) Theoretical studies in any field of modern astronomy or astrophysics, with or without associated experimental work. Prerequisites: Astro. 510, 511, 512.

BIOCHEMISTRY (BIOCH)

John H. Pazur, *Head of the Department*
109 Frear Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Clagett, Mallette, Pazur, and Sullivan; Associate Professors Phillips and Shigley; Assistant Professor R. Schraer.

Graduate Faculty, Associate Members: Assistant Professors Loerch, McCarl, and Steinman.

Opportunities for research and graduate study are available in plant metabolism and photosynthesis, intermediary metabolism, nucleic acids, proteins, carbohydrates, lipides, enzymes, clinical chemistry, and endocrinology.

Entering graduate students should have had at least one year's work in each of the following: general chemistry, analytical chemistry, organic chemistry, physical chemistry, and general physics. Mathematics through integral calculus is also required. Students with limited deficiencies in these subjects may be admitted but must make up such deficiencies concurrently with their graduate studies. Undergraduate courses in biology, biochemistry, and foreign languages will be helpful to the student but are

not required for admission. The Corn Products Lectures in Biochemistry enable the department to bring to the campus each year some distinguished visiting lecturers.

For courses offered at the Milton S. Hershey Medical Center see pages 245 to 248

BIOCHEMISTRY (BIOCH)

401. General Biochemistry (3) *Mr. Clagett*
402. General Biochemistry (3) *Mr. Clagett*
403. Laboratory in Experimental Biochemistry (2)
404. Food Chemistry (3-4)
417. Biochemical Methods (4) *Mr. Loerch*
425. Biophysical Chemistry (4) *Mr. Mallette*
436. Physiological Chemistry (3) *Mr. Pritham*
437. Physiological Chemistry (3) *Mr. Pritham*
438. Clinical Methods (3) *Mr. Pritham*
439. Independent Study (1-12)

501. Enzymes (2) Investigations and theories concerning nature of enzymes, enzyme action, influence of chemical environment on enzyme action, and biological applications. Prerequisite: Bioch. 402 or 437. *Mr. Clagett*

503. Biochemical Problems (1-10 per term) Prosecution of an assigned problem under the guidance of an instructor. *Mr. Loerch*

507. Seminar in Biochemistry (1 per term)

510. Proteins, Amino Acids, and Peptides (2) Organic, physical, and biological chemistry of the naturally occurring compounds of this group. Prerequisites: Bioch 425; 402 or 437. *Messrs. Mallette and Steinman*

511. Carbohydrates (2) Chemical constitution and properties of carbohydrates; their metabolism in plant and animal organisms. Prerequisite: Bioch. 402 or 437. *Mr. Pazur*

512. Lipides (2) Investigations on biochemistry of fats and related substances. *Messrs. Shigley and McCar*

516. Chemistry of the Pesticides (2) Lectures and assigned readings on the chemistry of insecticides, fungicides, herbicides, rodenticides, and related materials. Prerequisites: Chem. 31; Bioch. 402 or 437.

517. Endocrine Secretions (2) Chemistry of hormones and their physiological significance. Prerequisite: Bioch. 402 or 437.

519. Intermediary Metabolism (3) Processes involved in the utilization of metabolites in plants and animals. Prerequisite: Bioch. 402. Spring term. *Messrs. Mallette and Phillips*

520. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on proteins and enzymes. Prerequisite or concurrent: Bioch. 501, 510. *Messrs. Clagett and Mallette*

521. Biochemical Methods (3) Lectures and advanced laboratory on current techniques pertaining particularly to research on lipides and carbohydrates. Prerequisite or concurrent: Bioch. 511, 512. *Mr. Shigley*

530. Special Topics in Biochemistry (2-4)

BIOLOGICAL SCIENCE (BI SC)

EDWARD D. BELLIS, *Chairman of the Committee on Biological Science*
311 Life Sciences Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Anderson, Anthony, Cheng, Cooper, Fergus, Grun, Hale, Kneebone, Kovar, and Wright; Associate Professors Bellis, Hamilton, Hymer, and Lytle.

Graduate Faculty, Associate Members: Associate Professors Hillson, Pursell, Wickerham, and Wood; Assistant Professor Witham.

The M.Ed. program in biological science is designed primarily to meet the needs of secondary school science teachers. The academic degrees M.S. and Ph.D. are not offered in biological science but are available in biochemistry, biophysics, botany, entomology, genetics, microbiology, physiology, plant pathology, and zoology.

In order to enter a program for a higher degree with a major in biological science, the candidate should present 30 credits in the natural sciences, including one year of organic chemistry and one year of physics. A limited number of undergraduate deficiencies may be made up in pursuit of the advanced degree.

The candidate for the M.Ed. degree must earn at least 24 credits in the natural sciences with a minimum of 15 credits in the biological sciences, including at least 6 in the animal sciences and 6 in the plant sciences. In addition, at least 6 credits in educational foundations and a term paper are required.

The D.Ed. program is designed for secondary school and college science teachers. Major course requirements are designated by the candidate's committee with the concept that teachers of biology have a broad background in biological disciplines and related fields. A minimum of 15 credits each is required in professional education and in thesis research. The requirement of a foreign language is at the discretion of the candidate's committee.

BIOPHYSICS (BPHYS)

ERNEST C. POLLARD, *Head of the Department*
618 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Ginoza, Person, Pollard, and H. Schraer; Associate Professors Deering, Smyth, Snipes, Strother, and Taylor.

Graduate Faculty, Associate Member: Assistant Professor Todd.

This program is designed for those interested in applying physical methods to the problems of living systems. A student with a degree in physics, biology, chemistry, or engineering is eligible for admission. Opportunity to make up possible undergraduate deficiencies is provided in the program.

Courses are offered in molecular biophysics (an introductory course), nucleic acids, radiation action, cellular physiology, biophysical instrumentation, general biophysics, physics of viruses, and physics of the cell. Advice on the selection of other courses to meet the needs of each student is provided by the faculty. These include courses in physics, chemistry, biochemistry, zoology, botany, and microbiology.

BIOPHYSICS (BPHYS)

410. Special Topics (1-6)
430. (Biol. 430) Molecular Biology of the Gene (3)
473-474-475. Biophysics (2 each)

580. Biophysical Science (3) Theory of muscular contraction, heart action, a nerve conduction; X-ray analysis of proteins and nucleic acids; enzyme kineti and thermodynamics.

581. Radiation Biophysics (2) The action of ultraviolet and ionizing radiati and of radioactive decay on biological systems: molecular and cellular aspec Prerequisite: Bphys. 474.

582. Biophysics of Nucleic Acids (3) Biophysical studies on the structure a function of the nucleic acids, particularly those of bacterial and viral origin.

583. Special Topics in Biophysics (1-6 per term)

584. Seminar in Biophysics (1-3 per term)

585. Electron Microscopy in Biological Science (3) Principles of electr microscopy and application of techniques for the study of the ultrastructure of bi logical materials. Prerequisite: any of the following—Bphys. 473; Biol. 405, 43 Micrb. 401.

586. Biological Macromolecules (3) Biopolymer characteristics; polymer st tistics; size and shape determination; methods of separation; polyelectrolytes; optic and mechanical properties; denaturation; degradation; biosynthesis. Prerequisit Bphys. 475 or Chem. 451.

587. Ultracentrifugation (2) A laboratory course in ultracentrifugation tec niques including applications to biophysical problems. Prerequisite: Bphys. 47

588. Physiology of Nerves, Muscles, and Sense Organs (2-6) Current liter ture on the function of excitable tissues of insects and other animals. Prerequisit a 400-level course in physiology, biophysics, or physiological psychology.

589. Mammalian Cell Culture (3) Recent research in quantitative cell biolo as studied with tissues and cells of higher organisms cultured *in vitro*. Prerequisit Bioch. 401.

590. Photobiology (2) Effects of visible and ultraviolet light on biological sy tems: energy absorption, transfer, utilization; photochemistry; metabolic and g netic responses; repair systems.

591. Microspectrophotometry (2) Principles of absorption spectroscopy; micr spectrophotometer design; determination of cellular constituents using strained a unstrained preparations; laboratory exercises. Prerequisite: graduate student stan ing.

595. Electron Spin Resonance Spectroscopy (3) Experimental and theoretic aspects of electron spin resonance spectroscopy to provide ability for its applicati to biophysical problems. Prerequisite: basic knowledge of quantum mechanics a electromagnetic waves.

BOTANY (BOT)

C. Leonard Fergus
In Charge of Graduate Programs in Botany
202 Buckhout Laboratory

)egrees Conferred: Ph.D., M.S.

;raduate Faculty, Senior Members: Professors Fergus, Grove, Grun, Kneebone, Kovar,)'Mara, Schein, Spackman, and Wright; Associate Professor Hamilton.

;raduate Faculty, Associate Members: Associate Professors Hillson, Pursell and Tra-erse; Assistant Professors Costantino, Keener, Therrien, Wagner, and Witham.

Botanical programs are offered in plant anatomy, cytology, ecology, genetics, mor-hology, mycology, physiology, and taxonomy. A student having a degree in science r in one of the biological sciences is eligible for admission. Entering graduate stu-ents should have had basic courses in chemistry, mathematics, and physics.
See also Genetics and Physiology.

;IOLOGY (BIOL)

00. Comparative Plant Morphology (4)
05. General Cytology (3)
07. Plant Anatomy (3)
11. Plant Biology for Teachers (3)
12. Plant Biology for Teachers (3)
14. Taxonomy of Vascular Plants (3)
18. Mycology (3)
20. (Geol. 420) Paleobotany (3)
22. Advanced Genetics (3)
23. (Geol. 423) Introductory Palynology (3)
24. Botanical Technique (3)
41. Plant Physiology (3)
42. Plant Physiology (3)
43. Plant Physiology (3)
50. Plant Autecology (3)
51. Plant Synecology (3)
81. Aquatic Botany (3)

00. Plant Physiology Seminar (1 per term) Selected topics from recent literature; staff and student reports on current research. Spring term, even years.

02. The Physiology of the Fungi (3) Chemical composition, metabolism, toxic and stimulating agencies, spore germination, growth and irritability of the fungi. Fall term, even years.

05. Cytology and Cytogenetics (3) Chromosome mechanism of heredity; relationship between plant and animal evolution and breeding and changes in chromosomes; cytological and cytochemical techniques. Prerequisite: Biol. 405 or 422.

06. Comparative Anatomy of Vascular Plants (3) Structure of the Tracheophyta from a phylogenetic standpoint. Prerequisite: Biol. 407. Spring term, even years.

11. Advanced Plant Physiology (3) Physiology of plants including uptake of water and minerals, translocations, mineral nutrition, energy relations, respiration, and catabolism. Prerequisite: Biol. 442. Fall term.

512. Advanced Plant Physiology (3) Continuation of Biol. 511. Physiology o plants including photosynthesis, synthesis of cellular constituents, growth and de velopment. Prerequisite: Biol. 442. Winter term.

516. Ecological Plant Geography (3) Distribution of plant communities; en vironmental factors which influence their present distribution; geological-historic development of plant communities, their past distribution. Winter term, odd year

518. Special Problems (1-12) Prosecution of an assigned problem under th guidance of a staff member. Throughout the year as arranged. By appointment.

521. Medical and Industrial Mycology (3) Structure, life histories, classifica tion, and techniques of study of the fungi pathogenic to man and of fungi impo tant in industry. Fall term, odd years.

522. Myxomycetes, Phycomycetes, and Ascomycetes (4) Morphology, taxono my, phylogeny, and life histories; identification and field work. Prerequisite: Bio 418. Winter term, even years.

523. Basidiomycetes and Fungi Imperfecti (4) Morphology, taxonomy, phy logeny, and life histories. Prerequisite: Biol. 418. Spring term, even years.

524. Seminar in Genetics (1 per term)

526. (Geol. 526) Problems in Palynology (1-6) Systematics; paleoecologic palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocen vegetational history.

528. Biometrical Genetics (3) Hereditary structure of populations fusing th principles of genetics, mathematics and statistics, genetic analysis of quantitativ traits, artificial selection theory. Prerequisites: Biol. 428 and Stat. 402 or Agro. 54

531. Bryology (3) Morphology, taxonomy, and ecology of liverworts, hornwort and mosses; collection, preservation, culturing, and cytologic techniques. Sprin term, even years.

533. Problems in Genetics (2-6) Problems to suit needs of individual student conferences and laboratory work.

535. Morphology of the Tracheophyta Exclusive of Angiosperms (3) Origi developmental tendencies, structure, and paleobotanical evidence. Winter ter odd years.

536. Morphology of Angiosperms (3) Floral origin and development, fertiliz tion, embryogeny, seed and fruit development. Prerequisite: Biol. 400.

537. (Sec.Ed. 537) Workshop in the Biological Sciences (3) Projects d signed for teachers of biology in the secondary schools. Summer term only.

540. Phycology (4) Comparative morphology, taxonomy, and ecology of fres water and marine algae; culturing, collection, preservation techniques. Prerequ site: Biol. 424.

Note: *See Zoology for additional courses.*

BUSINESS ADMINISTRATION (B A)

MAX D. RICHARDS
In Charge of Graduate Programs in Business Administration
102A Boucke Building

Degrees Conferred: Ph.D., M.S., M.B.A.

Graduate Faculty, Senior Members: Professors Beranek, Bradley, Carzo, Cook, Coyle, Ferrara, Gotterer, Greenlaw, Kelley, McKinley, Pashek, Philips, Richards, Rigby, Schrader, Strong, Waters, and Wherry; Associate Professors Babione, Copeland, Cramer, Hammond, and Spier.

Graduate Faculty, Associate Members: Professors Nelson, Phalan, and Williams; Associate Professors Beik, Bennett, Clewett, Heitmann, Hottenstein, Malcom, Millman, Shilling, and Yanouzas; Assistant Professors Crumbley, Melander, and Slocum.

The M.B.A. program is designed for those desiring professional education in business administration, regardless of their educational background, in preparation for administrative positions primarily in business firms.

An applicant with little or no training in business administration may be admitted to the M.B.A. program and may be required to schedule up to 30 undergraduate credits of preparatory courses while pursuing the graduate program. Three credits are required as preparatory courses in accounting, business law or legal environment of business, business statistics, calculus, financial management, finite mathematics, macroeconomics, microeconomics, management, and marketing.

The M.S. and Ph.D. programs with a major in business administration are designed for those interested primarily in research and teaching.

For admission to the M.S. program approximately 30 acceptable undergraduate credits in business administration, economics, and mathematics may be required. An applicant may be admitted with deficiencies to be made up without degree credit.

Applicants to any of the graduate programs in business administration are required to take the Admission Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service and used by leading graduate business schools throughout the country to supplement other criteria for admission. Candidates are strongly urged to take the test at the earliest possible date. The test is given at University Park and at numerous locations in most states and foreign countries in November, February, April, and July. For dates and locations, see the *Bulletin of Information,* Admission Test for Graduate Study in Business, Educational Testing Service, Princeton, New Jersey. Applicants should read the bulletin carefully. All arrangements for taking the test are made directly with the Educational Testing Service.

This graduate program is accredited by the American Association of Collegiate Schools of Business.

ACCOUNTING (ACCTG)

401. ADVANCED ACCOUNTING (3)
403. AUDITING CONCEPTS AND TECHNIQUES (3)
404. MANAGERIAL ACCOUNTING (3)
406. ADVANCED FEDERAL TAX ACCOUNTING (3)
409. MACHINE AND ELECTRONIC ACCOUNTING METHODS (3)

*398G. ACCELERATED ELEMENTARY ACCOUNTING (3) The theory and technique of financial and managerial accounting: preparation, analysis, and interpretation of financial statements. Open to graduate students only.

500. Accounting Seminar (3-6)

503. Seminar in Auditing (3) The attest function of independent public account ants, verification of financial statements; problems of evidence, independence, eth ics, professional responsibilities. Prerequisite: Acctg. 403.

504. Seminar in Managerial Accounting (3-6) Accounting and the manageria processes of planning, control, and decision-making.

507. Seminar in Financial Accounting (3) Theoretical basis of financial ac counting.

508. Contemporary Issues in Accounting (3) Selected problems of current in terest to the accounting profession.

511. Interpretation of Account Data (3)

515. Development of Accounting Thought (3) Development of accountin thought from ancient civilizations to the present.

520. Problems in Accounting (3-6) Planned individual projects involving li brary, laboratory, or field work.

BUSINESS ADMINISTRATION (B A)

462. Problems in Trade and Transportation (3)

503. Seminar in Public Utilities (3)

540. Business Administration Theory and Practice (3) An integrating cours primarily for M.S. students using cases requiring analysis involving interrelate aspects of business administration and control.

550. Behavioral Science in Business (3) Application of behavioral science con cepts and analytical methods to problems in business organizations. Analysis o administrative behavior and decision making.

552. Business Research Methods (3) Research methods applicable to busines problems with emphasis on means of obtaining data and the logic underlying re search design.

555. Business and Society (3) Evolution of the business organization and th changing framework of its operations, responsibilities, and social control.

574. Business Research (1-3) A project paper, comparable in quality and scop of work to a graduate thesis, on problems of a company. Prerequisite: 15 credit of 400 and 500 courses in business administration.

577. Administrative Integration (3) An analysis of coordination of the func tional areas of business in relation to over-all company objectives. Prerequisite: 1 credits of 400 and 500 courses in business administration.

BUSINESS LAW (B LAW)

*398G. Accelerated Business Law (3) Social control through law: courts; poli cies underlying individual rights; negotiable and non-negotiable contractual right in society. Open to graduate students only.

* No graduate credit is given for this course.

BUSINESS LOGISTICS (B LOG)

410. Transportation and Public Policy (3)
412. Transportation Decision Techniques (3)
420. Urban Transportation (3)

504. Problems in Business Logistics (3-6) Planned individual projects involving library, laboratory, or field work.

538. Transportation and Physical Distribution (3) Control of the movement of goods; coordination of supply and demand in creation and maximization of time and place utility.

565. Seminar in Business Logistics (3-6)

FINANCE (FIN)

406. Investment Valuation and Management (3)
408. Credit Institutions (3)

*398G. Accelerated Financial Management (3) Financial planning and forecasting; management of working capital, capital budgeting, and dividend policy; capital structure and valuation. Open to graduate students only.

504. Problems in Finance (3-6) Planned individual projects involving library, laboratory, or field work.

531. Financial Management (3) An intensive examination of techniques available to aid the financial manager in decision-making.

541. Financial Theory (3) A theoretical analysis of the elements of finance.

561. Seminar in Finance (3-6) Comparative analysis of research in the theories of finance; relationships to business management practices.

INSURANCE (INS)

400. Estate Planning (3)

500. Insurance Theory and Practice (3) Insurance as an institution, a technique, a legal contract; its environment as a regulated industry.

504. Problems in Insurance (3) Planned individual projects involving library, laboratory, or field work.

510. Risk Management (3) Analysis of managerial problems and responsibility for risk analysis, removal or reduction, and allocation of corporate resources to provide indemnity.

520. Seminar in Insurance (3-6) Selected topics on advanced aspects of risk management with emphasis on the insurance technique for treating hazards.

INTERNATIONAL BUSINESS (I B)

501. The International Environment (3) Conceptual approach analyzing and predicting influences of social, political, and economic norms and values upon diverse societies' managerial decision-making.

* No graduate credit is given for this course.

502. International Business Macro Theory and Policy I (3) International economic trade and monetary tools are applied to current national policy issues to determine effects on international business operations. Prerequisite: Econ. 333.

503. International Business Micro Theory and Policy I (3) Analysis of the internal operations of multinational firms; design of optimal strategies of operation under varying environmental conditions. Prerequisite: I.B. 502.

504. Seminar in International Business (3-6) Seminar techniques applied to selected topics; market structures; capital budgeting, investment; comparisons of foreign norms and values; multinational organization characteristics.

MANAGEMENT (MGMT)

430. Administrative Management (3)
432. Simulation of Management Systems (3)
435. Cases in Public Relations (3)

*398G. Accelerated Business Management (3) The concepts of management and its decision processes including special attention to operations management.

510. Operations Management (3) Integration and application of decision-making to operational and policy problems within the business firm.

520. Organization Theory (3) Theoretical and operating structures in formal business organizations; relation of formal organization to informal groups and to individuals.

522. Personnel Management (3) Theoretical constructs underlying personnel administration; analysis of professional personnel functions in business firms.

530. Seminar in Management (3-6) Comparative analysis of research in the theories of the administrative sciences; relationships to business management practices.

531. Management Information Systems (3) Information system theories and methods applied to administrative structures and management decisions in organizations.

MARKETING (MKTG)

424. Marketing Research (3)

*398G. Accelerated Marketing Management (3) Analyses of customer and market behavior, marketing systems, and competitive strategies; programming product, pricing, distribution, and promotion. Open to graduate students only.

500. Marketing Management (3) Analysis of management's marketing problems including market analyses, pricing, channel of distribution, promotion, competition, product strategies, and marketing research.

504. Problems in Marketing (3-6) Planned individual projects involving library, laboratory, or field work.

510. Planning Market Strategy and Programs (3) Development of marketing strategy for the firm and design of integrated product-service, promotion, and distribution programs utilizing systems analysis.

520. Quantitative Analysis for Marketing Decisions (3) Sales forecasting, new product proposals, media selection, and market testing analyzed using statistical and decision theory and other mathematical techniques.

* No graduate credit is given for this course.

530. Consumer and Market Behavior (3) Buying behavior: Concepts from the behavioral sciences, including utility, culture, life cycle, personality, attitudes, and learning.

540. Marketing and Society (3) Marketing problems of society; domestic and regional marketing systems; governmental policies toward marketing; social performance of marketing.

544. Marketing Theory (3) The development of marketing concepts, behavioral and other marketing theories; public policy and the role of marketing in societies.

560. Seminar in Marketing (3-6) Research in modern marketing trends.

QUANTITATIVE BUSINESS ANALYSIS (Q B A)

403. Intermediate Business Statistics (3)
404. Sampling in Business Operations and Research (3)
451. Analytical Methods in Business (3)
452. Analytical Methods in Business (3)
461. Probabilistic Models in Business (3)
490. Special Topics (3-6)

*398G. Accelerated Business Statistics (3) Basic characteristics of univariate and bivariate distributions, probability theory, introduction to estimation, tests of hypotheses, and time series analysis. Open to graduate students only.

500. Seminar in Business Statistics (3-6)

501. Advanced Business Statistics (3)

510. Statistics in Business Research (3) Statistical principles and procedures essential to the interpretation and performance of research in business administration. Prerequisite: common requirements of M.B.A. program.

521. Quantitative Analysis for Business Decisions (3) Construction and use of quantitative models in business decision-making. Prerequisite: common requirements of M.B.A. program.

REAL ESTATE (R EST)

400. Urban Land Utilization (3)

BUSINESS EDUCATION (BUS ED)

F. Wayne House
In Charge of Graduate Programs in Business Education
253 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Member: Professor House

This program provides advanced preparation for teachers of business subjects for

* No graduate credit is given for this course.

secondary schools and colleges. The subject-matter areas encompass secretarial, accounting, retailing, clerical, and general business sequences. The program may be adapted for the preparation of supervisors of business education.

A minimum of 18 acceptable undergraduate credits in education and psychology plus a minimum of 30 credits in business and business education subjects are required for admission.

All candidates specializing in business education are encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanities.

BUSINESS EDUCATION (BUS ED)

456. Principles and Problems in Business Education (1-3)
459. Improvement of Instruction in Business Skill Subjects (1-3)
460. Curriculums in Business Education (3)
461. Improvement of Instruction in Basic Business Subjects (3)
462. Teaching of Shorthand and Typewriting (3)
463. Teaching of Bookkeeping (3)

511. Internship in Business Education Supervision (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

575. Administration and Supervision in Business Education (3) Work of administrators, supervisors, and others responsible for improvement of instruction in business education; use of vocational testing; job analysis. Prerequisite: 6 credits in secondary education.

576. Introduction to Research in Business Education (3) Methods of research in business education; opportunity to compile annotated bibliographies on current problems; analysis and evaluation of significant research.

577. Evaluation of Research and Empirical Literature in Business Education (3) Application of evaluation methods to current literature in business education; special attention to research studies. Prerequisite: Bus.Ed. 576.

578. Seminar in Business Education (1-6) Intended for graduate students preparing theses or final documents, or for those working on special studies in business education. Prerequisite: Bus.Ed. 577.

CERAMIC SCIENCE (CER SC)

Floyd A. Hummel
In Charge of Graduate Programs in Ceramic Science
201 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Faust, Hummel, Rindone, and Williamson; Associate Professor Stubican.
Graduate Faculty, Associate Members: Assistant Professors Bradt and McKinstry.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree.

The background for admission is a bachelor's degree in ceramics or in one of the related physical sciences. A knowledge of differential and integral calculus is required together with adequate physics and chemistry.

In view of the wide field covered by ceramic science, the graduate courses may be selected with a bias toward physical ceramics, chemical ceramics, or glass technology. This makes it easily possible for students whose major subject for the bachelor's or master's degree has been either physics or chemistry to take appropriate graduate studies in ceramic science.

Special facilities exist for research in the areas of clay mineralogy, phase equilibria, mineral synthesis, mechanical properties, ferrite and ferroelectric studies, glass technology, and high temperature reaction kinetics.

CERAMIC SCIENCE (CER SC)

400.	(Min. 400) Nonmetallic Crystal Chemistry (2)	*Mr. Brindley*
402.	Principles of Ceramic Engineering (3)	*Mr. Williamson*
404.	Ceramic Seminar (1)	*Mr. Hummel*
405.	Ceramic Research and Design (1)	
406.	Rheology and Fluid Properties of Ceramic Systems (2)	*Mr. Williamson*
407.	Ceramic Materials Laboratory (2)	*Mr. Williamson*
408.	Heat Treatment of Ceramic Materials (1)	*Mr. Stubican*
409.	Heat Treatment Laboratory (2)	*Mr. Stubican*
410.	Phase Relations in Ceramic Systems (3)	*Mr. Hummel*
411.	Principles of Ceramic Processes (2)	*Mr. McKinstry*
414.	Mechanical Properties of Ceramics (3)	*Mr. Bradt*
415.	Principles of Glass Technology (3-4)	*Mr. Rindone*
420.	Refractories (2-3)	*Mr. Stubican*
425.	Ceramic Research and Design (2)	
430.	Electroceramics (2-3)	

500. Seminar in Ceramic Science (1-2 per term) Current developments in ceramic science and related fields. Required of all graduate students in ceramic science. *Mr. Hummel and Staff*

501. Colloidal Behavior of Clays and Muds (2-4) Surface chemistry of clays; rheology of ceramic powders, suspensions, and pastes. *Mr. Williamson*

503. Use of Phase Equilibria Data in Ceramic Science (2-5) Phase equilibria in unary, binary, ternary, and other systems; applications in product development and in understanding behavior of ceramic materials. *Mr. Hummel*

504. Solid State Reactions in Ceramic Systems (2) Thermodynamic, kinetic, and structural study of reactions and of equilibrium in ceramic systems. Prerequisites: Chem. 451, 452. *Mr. Brindley*

506. Mechanical Properties of Ceramics (3) Theoretical consideration of internal stresses, dislocations and dislocation processes, and macro- and microstructural variables on the mechanical properties of ceramics. Prerequisite: Cer.Sc. 414. *Mr. Bradt*

507. Thermal Properties of Ceramic Materials (2-3) Heat capacity, heat of fusion, thermal conductivity, and thermal expansion in relation to macroscopic measurements and basic atomic concepts applied to ceramic materials. *Mr. Stubican*

508. Dielectric and Magnetic Properties of Ceramic Materials (2-3) Preparation and properties of ceramic semiconductors, dielectrics, and magnetic materials.

509. Composite Materials (3) Manufacturing processes, atomic and molecular background, and topological relationships of macro- and microstructure to the physical properties of composites.

510. Seminar in Glass Technology (1-2 per term) Current developments in glass technology and related fields. *Mr. Rindone*

511. The Constitution of Glass (2-3 per term) Historical and current concepts of the atomic structure of glass; relationship of structure to chemical and physical properties. *Mr. Rindone*

512. Selected Properties of the Vitreous State (2-3 per term) Measurement and interpretation of such properties as: radiation effects; viscoelasticity; electrical, mechanical, optical, and thermal properties. *Mr. Rindone*

515. Special Problems in Ceramic Science (1-6 per term) Advanced individual study on a problem in ceramics.

516. Selected Topics in Ceramic Science (1-3 per term) Intensive group study of special topics.

530. (Min. 530) Structure, Properties, and Occurrence of Clay Minerals (2-5) Structure analysis and identification of clay minerals; mineral transformation and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Messrs. Brindley and Hsu*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in ceramic science studies are listed under Mineral Sciences.*

CHEMICAL ENGINEERING (CH E)

Merrell R. Fenske, *Head of the Department*
133 Chemical Engineering Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Braun, Fenske, Jones, Klaus, McCormick, and Quiggle; Associate Professors Engel and Hersh.

Graduate Faculty, Associate Members: Associate Professors Daubert and Kabel, Assistant Professors Barton and Evans.

Course offerings or research facilities are available in the following areas: phase equilibria, thermodynamics, kinetics, mass transfer, transport phenomena, unit operations, unit processes, nuclear chemical engineering, applied chemistry and petrochemistry, petroleum technology, rheology, and lubrication. The facilities for instruction and research in chemical engineering and petroleum chemistry include those of the Petroleum Refining Laboratory.

To be admitted, a student should be a graduate of an accredited major in chemical engineering or the equivalent. Graduates of other accredited engineering or physical science majors may be admitted but will be required to make up certain undergraduate deficiencies without graduate credit.

CHEMICAL ENGINEERING (CH E)

404.	Chemical Engineering Economics (3)	*Mr. Engel*
405.	Thermodynamics for Chemical Engineers (3)	
406.	Chemical Engineering Problems (3)	*Messrs. Engel and Barton*
410.	Chemical Engineering Principles (3)	*Messrs. Daubert and Evans*
411.	Chemical Engineering Principles (3)	*Messrs. Daubert and Evans*
412.	Chemical Engineering Principles (3)	*Messrs. Daubert and Evans*
415.	Analysis and Mathematical Simulation in Chemical Engineering (3)	
420.	Cryogenic Engineering (3)	
422.	Petroleum Processes and Products (2)	*Mr. Kabel*
426.	Introduction to Transport Phenomena (3)	*Mr. Engel*
430.	Nuclear Chemical Engineering (3)	*Mr. Evans*
435.	Chemical Reaction Kinetics (2)	*Mr. Kabel*
440.	Chemical Engineering Materials (3)	*Mr. Engel*
445.	Chemical Engineering Research (1-5)	
450.	Process Dynamics (3)	
460.	Chemical Engineering (4)	*Mr. Barton*

500. Seminar in Chemical Engineering (1) Required of all graduate students.

505. Special Topics in Chemical Engineering (2-12) Intensive study in the various specialized fields of chemical engineering.

508. Principles of Industrial Organic Chemistry (3) Principles and practices of modern conversion processes in the manufacture of organic chemicals. Prerequisites: Chem. 31, 452, Ch.E. 30.

509. Heat Transfer Applications (3) Advanced treatment of steady-state and transient conduction, convection, and radiation, with emphasis on numerical methods and design techniques. Prerequisite: an undergraduate course in heat transfer.

515. Distillation (3) Commercial distillation, equilibrium diagrams, vapor composition, stills and rectifying and stripping columns.

516. Methods of Process Design (3) Survey of mathematical techniques of chemical process design with emphasis on economic choice and optimal decision making.

520. Extraction Processes (3) Equilibrium extraction data and phase contacting and settling related to equipment design.

521. Transport Phenomena (3) Momentum, heat, and mass transfer in boundary layers and turbulent fluids; ideal potential flow; unsteady state and coupled transport.

522. Special Topics in Transport Phenomena (3) Intensive group study and discussion of current problems and techniques in transport processes. Prerequisite: Ch.E. 521.

524. Chemical Engineering, Application of Thermodynamics (3) Elements of thermochemistry and thermodynamics of greatest importance in chemical engineering.

530. Heat Transfer in Nuclear Reactors (3) Fluid flow, heat transfer, and design problems in nuclear reactor systems.

535. Chemical Reaction Engineering (3) Optimal design of batch and continuous chemical reactors and reactor batteries; effect of mixing on reactor operation. Prerequisite: Ch.E. 435.

CHEMISTRY (CHEM)

THOMAS WARTIK, *Head of the Department*
212 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Deno, Dixon, Fritz, Haas, Hisatsune, Jackman, Jordan, Lampe, Miller, Noll, Oakwood, Shamma, Skell, Steele, Wartik, and Zook; Associate Professors Allcock, Ascah, Benkovic, Bernheim, Hamilton, Hayes, Heicklen, Olofson, Richey, and Rosenblatt.

Graduate Faculty, Associate Members: Assistant Professors Baldwin, Crawford, Gold, Long, Lotz, Lowe, Morris, Riehl, and Stanko.

Students may specialize in analytical, inorganic, organic, or physical chemistry. The general facilities are excellent, and the computer, cryogenic, petroleum, radiochemical, and spectroscopy laboratories provide unusual research opportunities. Distinguished visiting scholars conduct informal discussions each Thursday at a departmental colloquium. In addition, the Corn Products Lectures in Advanced Chemistry are presented each spring. These thirty lectures, by distinguished visiting scientists-in-residence, are devoted to in-depth descriptions of frontier investigations in chemistry.

For admission, at least integral calculus plus one year's work in general physics, organic chemistry, physical chemistry, and either analytical or inorganic chemistry is normally required.

Prior to scheduling their first term programs, new students will take examinations in the four areas of analytical, inorganic, organic, and physical chemistry. The information obtained from these tests will assist both the student and his adviser in making up a program best suited to the student's needs. These examinations are normally given just prior to the regular registration period.

CHEMISTRY (CHEM)

400. CHEMICAL LITERATURE (1)
401. SEMINAR (1)
405. NUCLEAR AND RADIOCHEMISTRY (3)
410. INORGANIC CHEMISTRY (4)
411. ADVANCED INORGANIC CHEMISTRY (2)
423. ADVANCED ANALYTICAL CHEMISTRY (3)
424. ADVANCED ANALYTICAL LABORATORY (2)
426. CHEMICAL INSTRUMENTATION (3-5)
431. ADVANCED ORGANIC CHEMISTRY LABORATORY (3)
435. ADVANCED ORGANIC CHEMISTRY LABORATORY (3)
439. ADVANCED ORGANIC CHEMISTRY (3)
448. COLLOID CHEMISTRY (3)
*451-452. PHYSICAL CHEMISTRY (3 each)
453. ADVANCED PHYSICAL CHEMISTRY (3)
454. ADVANCED PHYSICAL CHEMISTRY (3)
455. PHYSICAL CHEMISTRY OF HIGH POLYMERS (3)
*457-458. EXPERIMENTAL PHYSICAL CHEMISTRY (1 each)
489. INTRODUCTION TO CHEMICAL RESEARCH (1-10)
490. ORGANIC CHEMISTRY FOR TEACHERS (4)
492. ADVANCED GENERAL CHEMISTRY FOR TEACHERS (3)

500. SEMINAR IN INORGANIC CHEMISTRY (1 per term)

*Graduate credit not allowed for students majoring in chemistry or chemical engineering.

501. Seminar in Physical Chemistry (1 per term)

502. Seminar in Organic Chemistry (1 per term)

503. Seminar in Analytical Chemistry (1 per term)

516-517. Inorganic Chemistry (3 each) Systematic treatment of inorganic chemistry in terms of modern concepts.

518. Special Topics in Inorganic Chemistry (3 per term) Modern developments in specialized fields.

525. Analytical Processes (3) Theoretical foundations and contemporary developments.

526. Modern Instrumental Analysis (3)

527. Special Topics in Analytical Chemistry (2-12)

531. Special Topics in Organic Chemistry (3-12)

534. Theoretical Organic Chemistry (3) Modern theories of structure; resonance; interpretation of physical properties; theory of rates; equilibrium properties.

535-536. Organic Chemistry (3 each) Adapted to the needs of those doing research work in organic chemistry.

538. Organic Chemistry (3) Survey of organic chemistry arranged primarily for graduate students majoring in fields other than organic chemistry.

544. Chemical Thermodynamics (3) Development of thermodynamic theory with special reference to common physical changes and chemical reactions. Prerequisite: Chem. 452.

545. Statistical Thermodynamics (3) The calculation of thermodynamic properties from molecular and spectroscopic data. Prerequisites: Chem. 544, 565.

560. Topics in Physical Chemistry (2-6)

563. Chemical Kinetics (3) Theory and measurement of the rates of chemical reactions, molecular dynamics, and mechanisms of chemical reactions. Prerequisites: Chem. 544, 565.

565. Atomic and Molecular Structure (3) Introduction to modern theoretical chemistry, spectroscopy, and structure of atoms and molecules.

566. Quantum Chemistry (3) Theoretical calculations of electronic properties of atoms and molecules. Prerequisite: Chem. 565. Prerequisite or concurrent: Math. 555.

567. Quantum Chemistry (3) A continuation of Chem. 566, including problems and theories of electron correlation. Prerequisite: Chem. 566.

581. Experimental Methods in Petroleum Chemistry (1-12)

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CDFR)

Joseph H. Britton
In Charge of Graduate Programs in Child Development and Family Relationships
S-105E Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Britton, Harms, Harris, Morgan, and Smith; Associate Professors Broderick, de Lissovoy, and Urban.

Graduate Faculty, Associate Member: Professor Taylor.

Programs emphasize interdisciplinary study of growth, development, and aging and interpersonal processes in the family, the neighborhood, and the larger community. The perspective encompasses the human life span, socialization processes, and the individual's roles in marriage, parenthood, and other social institutions in various cultural settings. The faculty includes persons in the psychological and social sciences particularly committed to research and application in these interdisciplinary fields.

Students are expected to emphasize one area of study or professional orientation. They may prepare for positions in teaching and research in colleges, secondary and elementary schools, and in nursery schools; for work as human development specialists with children, parents, or other adults; and for service in community agencies.

The department operates preschool and infant laboratories as part of the teaching and research program. Each unit has observational facilities, and there are adjoining rooms for study of individual and group behavior of children and of adults. Additional resources, such as the Psychology Clinic, the Special Education Center for Children, the Speech and Hearing Clinic, and the Computation Center, are available in other parts of the University.

The entering student should have at least 6 credits in the biological and physical sciences, 12 in the social sciences (including a basic course in both sociology and psychology), and 6 in human development and family relationships. Students not meeting these requirements may be admitted with limited deficiencies to be made up concurrently with their graduate studies.

INDIVIDUAL AND FAMILY STUDIES (I F S)

410. Communities and Families (3)
413. Dysfunctions in the Developmental Process (3)
414. Resolving Individual and Family Problems (3)
415. Child Development and Family Relationships for Secondary Schools (3)
418. Family Relationships (3)
420. Problems in the Analysis of Individual Development (3-9)
427. Conceptions in Development (3)
428. Infant Development (3)
429. Advanced Child Development (3)
430. Practicum in Preschool Groups (1-6)
432. Developmental Problems of Normal Children (3)
435. Developmental Transition to Adulthood (3)
441. Organization Planning for Preschool Programs (3)
445. (Psy. 445) Development Throughout Adulthood (3)
481. Developmental Programming for Preschool Children (3)

CHILD DEVELOPMENT AND FAMILY RELATIONSHIPS (CDFR)

00. Nonthesis Research (1-9)

08. Parental Education (3) Discussion and use of methods, experiences, and programs which can be used effectively to help parents in dealing with problems of parent-child relationships.

15. The Teaching of Child Development and Family Relationships (3) Methods of selection and presentation of subject matter basic to understanding the development of children.

20. Infancy (3) Infant development, with emphasis on factors influencing development and the relationships of early experience to later behavior. Prerequisites: 6 graduate credits in child development and family relationships, psychology, or biological sciences and 3 credits in statistics.

29. (Psy. 529) Seminar in Child Development (1-6) Readings and reports on recent findings in child development. Prerequisites: 6 graduate credits in child development, child psychology, or educational psychology, plus 3 in statistics.

30. Problems in Child Development and Family Relationships (1-9) Problems involving individual research in library, laboratory, or field projects.

36. (Psy. 536) Research Methods in Child Development (3) Prerequisites: 6 credits in child development and a course in statistics.

45. The Family in Its Community (3) Cultural influences on family relationships; how the family orients its members to community living and group participation.

46. Seminar in Family Relationships (1-9) Reading, reports, and discussion of recent research in relationship aspects of family living; particular attention to studies of roles, crises, and adjustments within the family setting.

48. Survey of Research on Sexual Behavior (3) Survey and evaluation of the contributions to the studies of sex by H. Ellis, Freud, Malinowski, Terman, Kinsey, and others. Prerequisites: 12 credits at the 400 and 500 level in child development and family relationships, psychology, sociology, or anthropology; 3 credits in statistics.

49. (Psy. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application.

50. Perspectives in Child Development (3) Analysis of developmental studies since 1920. Examination of childhood in philosophy, education, literature, and art prior to 1920. Prerequisites: 6 graduate credits in psychology or child development and family relationships and 3 credits in statistics.

79. Seminar in Adult Development and Aging (1-9) A seminar dealing with specific topics concerning adult development and aging. Prerequisites: I.F.S. 445 and statistics.

CIVIL ENGINEERING (C E)

Benjamin A. Whisler, *Head of the Department*
212 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

CIVIL ENGINEERING

Graduate Faculty, Senior Members: Professors Brielmaier, Gotolski, Hurd, Kountz Larson, Nesbitt, Perez, and Whisler; Associate Professors Barnoff, Blue, and Reich.
Graduate Faculty, Associate Members: Associate Professors McDonnell and Weeden Assistant Professors Davinroy, Taylor, and Unz.

The entering student should be a graduate in civil engineering from an accredited college of engineering. Students may specialize in structures, hydraulics, hydrology transportation engineering, surveying, and sanitary engineering, or combinations o these. Relevant courses are offered both by the Department of Civil Engineering and by other departments of the University.
See also Sanitary Engineering.

CIVIL ENGINEERING (C E)

400. Seminar (1-3)
401. Civil Engineering Projects (2-12)
421. Highways and Streets (3)
422. Transportation Engineering (3)
423. Traffic Characteristics and Vehicle Safety (3)
424. Civil Engineering Materials (3)
427. Highway Geometric Design (3)
431. Civil Engineering Construction (3)
444. Engineering Soil Characteristics (3)
445. Soil Exploration and Analysis (3)
446. Advanced Soil Mechanics (3)
447. Structural Analysis by Matrix Methods (3)
448. Advanced Structural Design (3)
451. Advanced Hydrology (3)
452. Water Resources and Computations (4)
462. Open Channel Hydraulics (3)
465. River and Waterways Engineering (3)
471. Environmental Sanitation (3)
472. Water Pollution Control (3)

500. Seminar in Civil Engineering (1-6) Reports on researches and specia topics. Course may be continued in subsequent terms.

501. Civil Engineering Projects (3-10) Investigation or design projects in struc tures, transportation, hydraulics, or civil engineering materials.

520. Pavement Design (3) Fundamental principles; properties of pavement com ponents; design tests; design of flexible pavements; design of rigid pavements; pave ment evaluation and strengthening.

521. Analysis of Transportation Systems (3) Transportation systems, develop ment, classification characteristics, and analytical techniques.

522. Transport Operations (3) System elements, control devices, engineering design, administration to operation of transportation systems.

523. Urban Transportation Planning (3) Coordinated metropolitan transporta tion; characteristics of existing transportation systems, capacity, performance, costs and quality of service; parking, future concepts in transportation.

524. Advanced Problems in Civil Engineering Materials (2-6) Study, in the literature and by laboratory investigation, of selected topics on field-controlled civil engineering materials. Prerequisite: C.E. 424.

525. Airport Planning and Design (3) Aircraft characteristics; aeronautical demand; site selection; airport configuration; capacity analysis; design of landing and terminal areas.

526. Design of Transportation Facilities (3) Basic principles and engineering design of truck terminals, railroad yards and terminals, bus terminals, and parking facilities.

527. Theory of Traffic Flow (3) Phenomenon of vehicular traffic flow; flow density relationships; spacing; gap counting; delays; problems involving interrupted flow; multiflow routes.

528. Queuing Models in Transportation (3) Arrival patterns; the service mechanism; queue discipline; delays; multiple queues; problems involving various combinations of queues and service facilities.

540. Advanced Structural Analysis (2-4) Geometry of flexure; continuous beams, frames, arches; elastic foundations, elastic supports; beams curved in plan; grids; folded plates; domes. Prerequisite: C.E. 46.

541. Advanced Structural Analysis (2-4) Redundant, continuous, hybrid trusses; influence lines; secondary stresses; framed arches; suspension systems, selection of bridge type; space framing. Prerequisite: C.E. 46.

542. Applied Soil Mechanics (2-5) Soil classification by type of clay minerals and profile development; aerial photographic interpretation of soils and applications to site selection for dams, highways, and airports.

544. Advanced Structural Design (2-4) Concrete working stress, ultimate strength, limit design; test behavior of beams, slabs, columns; simple and continuous prestressed concrete members. Prerequisite: C.E. 42.

545. Advanced Structural Design (2-4) Steel, aluminum members; flexible connections; composite, hybrid, prestressed beams; tension-field beams; buckling; plastic analysis, design; test data; timber design. Prerequisite: C.E. 41.

548. Structural Design for Dynamic Loads (3) Dynamic behavior of structural systems of one and more degrees of freedom; earthquake, blast-resistant analysis, and design of structures.

550. Engineering Construction Management (2-4) Management fundamentals for construction contracting; organization, project planning, scheduling and control, bonding and insurance, labor legislation and regulation, cost and control. Prerequisite: C.E. 431.

551. Hydrologic Investigations (2-8) Application of hydrologic principles and techniques to a specific project.

560. Dimensional Analysis and Theory of Models (3) Principles of dimensional analysis and similitude with engineering applications.

564. Hydraulic Engineering Design (2-8) Design and analysis of selected units of a typical hydraulic engineering project.

565. Transportation of Solids by Fluids (2-5) Fundamentals of the flow of solids in open and closed conduits; e.g., suspended load and bed load in rivers, slurries and pulp stocks in pipes.

571. Water Treatment Theory (3) Theory of modern methods of conditioning water for municipal and industrial use. Prerequisite: C.E. 472.

572. Waste Treatment Theory (3) Theory of modern methods of waste treatment. Prerequisite: C.E. 472.

573. Advanced Problems in Sanitary Engineering (3-10) Investigations, analyses, and reports on current topics in sanitary engineering.

574. Analytical Evaluations in Sanitary Engineering (3) Experiments illustrating current chemical and biochemical methods of water and waste treatment and analytical methods used in research and control.

575. Advanced Industrial Waste Treatment (3) Techniques of industrial waste treatment; attendant stream pollution and stream self-purification factors. Prerequisite: C.E. 472 or 572.

576. Water Treatment Plant Design (1-6) Design of works for treatment of water for municipal and industrial use. Prerequisite: C.E. 71.

577. Sewage Treatment Plant Design (1-6) Design of works for treatment of sewage or industrial wastes. Prerequisite: C.E. 71.

580. Stream and Estuarine Analysis (3) Quantitative assessment of advection, reaction, and dispersion processes in polluted waters; reaeration theory; eutrophic systems; analog simulation. Prerequisite: C.E. 472.

CLASSICS (CLASS)

Anthony J. Podlecki, *Head of the Department*
103 Ihlseng Building

Degree Conferred: M.A.

Graduate Faculty, Associate Member: Associate Professor Podlecki.

Programs leading to the master's degree in this field offer opportunities for specialization in either Latin or Greek. The minimum requirement for admission to either program will normally be 18 undergraduate credits in either language. Provision is made, however, for admission with limited deficiencies. Candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

GREEK (GREEK)

420. The Greek Historians (3)
421. Greek Tragedy (3)
422. Greek Comedy (3)
425. Homer (3)
430. The Greek Philosophers (3-9)
450. Topics in Greek Literature (3-6)
451. History of the Greek Language (3)
498. Studies in Greek Literature (1-6)

507. Problems in Greek Archaeology (3-9)

509. Greek Seminar (3-9)

517. Greek Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

LATIN (LATIN)

420. The Latin Historians (3)
425. Latin Elegy (3)
426. Roman Comedy (3)
427. Vergil (3)
428. Lucretius (3)
430. Medieval Latin (3-6)
431. Roman Satire (3)
432. Roman Rhetorical and Literary Theory (3)
436. The Teaching of Latin (3)
437. Latin Prose Composition (3-6)
460. Topics in Latin Literature (3-6)
461. History of the Latin Language (3)
498. Studies in Latin Literature (1-6)

500. Latin Literature (3-9) Readings in the major forms of Latin literature; content varies, course may be repeated.

501. Roman Religion and Philosophy (3) Development of religious concepts at Rome from primitive Italic origins to the advanced forms that culminated in Roman Stoicism. Prerequisites: two 400-level courses in Latin.

510. Latin Seminar (3-6)

518. Latin Research (1-6) Prosecution of an assigned problem under the guidance of a member of the department.

*CLASSICS (CLASS)

401. The Classics and Archaeology (3)
405. Greek and Roman Mythology (3)
406. Emergence and Development of Classical Poetic Genres (3)
408. Greek Religion and Modern Man (3)
410. Classical Epic (3)
411. Classical Drama (3)
412. Classical Historians (3)
413. Readings in Classical Literature (3)

CLOTHING AND TEXTILES (CL TX)

Barbara E. Densmore
In Charge of Graduate Programs in Clothing and Textiles
S-118A Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Ayres and Tesi, Associate Professor Densmore.

Work may be taken with major emphasis in the textile area, which stresses the background natural sciences, or in the clothing area, which stresses the background

* The readings are in English; knowledge of Greek and Latin is not required.

social sciences. Candidates are accepted who have a strong foundation and a good record in any of the following: home economics, chemistry, sociology, economics, psychology, or art.

CLOTHING AND TEXTILES (CL TX)

400. Special Problems in Clothing and Textiles (1-6)
408. Intermediate Textiles: 408L (2), 408P (1-3)
410. Clothing for the Family (3)
415. Functional Clothing Design (3-12)
416. Western Costume Development from the Renaissance to the Present (3)

500. Nonthesis Research (1-6)

501. Recent Developments in Textiles (3) Developments in fibers, yarns, fabrics, finishes; effects on use and care; discussions and reports based on current literature.

506. Clothing Behavior (3) Analysis and interpretation of clothing behavior through the application of theories selected from the behavioral sciences.

507. Problems in Relation to Clothing Consumption (3) Problems connected with manufacture and consumption of clothing; interrelation of textile and clothing trades with other industries. *Mr. Tesi*

508. Special Problems in Clothing and Textiles (1-6) Individual directed study, investigation, and practice in selected phases of textiles and clothing.

509. Seminar in Clothing and Textiles (1-6)

510. Research Methods and Evaluation in Clothing and Textiles (1-6) *Miss Densmore*

511. Current Developments in Clothing and Textiles (1-6)

512. History of Clothing and Clothing Construction (3)

513. Advanced Textile Technology (6) *Miss Densmore*

COMPARATIVE LITERATURE (C LIT)

Philip A. Shelley
In Charge of Graduate Programs in Comparative Literature
203 Schwab Auditorium

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Bayard, Hyslop, Lewis, Pasquariello, Shelley, Townsend, and Weintraub; Associate Professors Oldsey, Wellwarth, and West.
Graduate Faculty, Associate Members: Associate Professors Podlecki and Timpe.

Programs are arranged through a meaningful selection of courses offered by the several departments of languages and literatures, both ancient and modern, as well as

of those specifically in the category of comparative literature. Subjects appropriate to such programs of study in international literary and cultural relations include the currency, reception, and influence of writers and works in countries other than those of their origin; the origin, transmission, and evolution of international literary movements; the characteristics and relations of universal literary types, themes, and motifs; literary intermediaries; literary criticism; folk literature and folklore.

In addition to the general requirements for the several degrees the following specific ones are in force:

Master of Arts: Three courses each in two national literatures and two in comparative literature; also a thesis in comparative literature. Language requirements: a thorough reading knowledge of one foreign language in case English is that of one of the literatures selected; otherwise a thorough reading knowledge of both languages of the two foreign literatures comprising the program of study.

Doctor of Philosophy: Beyond the work represented by the attainment of the master's degree in comparative literature or its equivalent, additional courses distributed approximately equal in number among three or four national literatures, including those presented for the master's degree. Additional work in courses specifically labeled comparative literature and a dissertation treating a subject in this field are required. Language requirements: a working knowledge of three foreign languages approved by the candidate's doctoral committee and aural competence in one modern language in addition to English.

COMPARATIVE LITERATURE (C LIT)

401. Western Literature I (3)
402. Western Literature II (3)
403. Western Literature III (3)
408. Heroic-Age Epics and Sagas (3) *Mr. Bayard*
443. (Ger. 443) Literary Relations of Germany with England and America (3-9) *Mr. Shelley*
470. Old Masters of the Modern Novel (3)
480. Introduction to Folklore (3) *Mr. Bayard*
486. Tragedy (3) *Mr. Wellwarth*
487. Comedy (3) *Mr. Wellwarth*
488. (Engl. 488) Modern Continental Drama (3) *Messrs. Weintraub and Wellwarth*
498. Special Subjects and Problems of Comparative Literature (3)

500. Seminar in Comparative Literature (3-6)

501. Comparative Method in Literary Studies (3)

508. Norse and Gaelic Sagas (3) Medieval Irish and Scandinavian prose tales surveyed and compared with respect to backgrounds, development, themes, and characteristics. *Mr. Bayard*

570. Forces in Contemporary European Literature (3) The intellectual currents that have influenced European writers of the mid-twentieth century: Beckett, Böll, Robbe-Grillet, and others. *Mr. West*

588. Twentieth Century Drama (3) Translation and comparative analysis of previously untranslated plays. Prerequisite: fluent reading knowledge of a foreign language. *Mr. Wellwarth*

COMPUTER SCIENCE (CMP SC)

PRESTON C. HAMMER, *Head of the Department*
426 McAllister Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Gotterer and Hammer, Associate Professors de Maine and Laird.

Graduate Faculty, Associate Members: Associate Professors Barnes, Day, McCammon and Singletary; Assistant Professors Deutsch, Honkanen, Hsu, Johnson, Jones, Squires Yeh, and Yntema.

The department offers courses and is prepared to direct research in a variety o subfields of computer science, including foundations of computer science, language and programming systems, numerical analysis, nonnumeric procedures, and heuristi methods. The Computation Center has modern digital equipment and systems avail able for research and instruction.

Admission to the M.S. program without deficiency requires the equivalent o Cmp.Sc. 401 and at least three of the five following: (1) Math. 441 or 481, (2 Cmp.Sc. 410, (3) Math. 453, (4) Math. 454, (5) Math. 428 or E.E. 471. Th remainder of these five must be completed for the M.S. or Ph.D.

The M.S. candidate must satisfactorily complete (a) Cmp.Sc. 510 or 511 and (b Cmp.Sc. 530 or 540, in addition to the other requirements of the Graduate School

Admission as a candidate for the Ph.D. normally requires completion of cours requirements for the M.S. and a background equivalent to an undergraduate majo in mathematics.

The Ph.D. candidate must pass three written examinations: one in a field of spe cialization, one in a field of mathematics, and the third in a related field approved b the doctoral committee.

COMPUTER SCIENCE (CMP SC)

401. PRINCIPLES OF PROGRAMMING WITH PHYSICAL SCIENCE APPLICATIONS (3)
402. PRINCIPLES OF PROGRAMMING WITH SOCIAL AND BIOLOGICAL SCIENCE APPLICATIONS (3)
403. PRINCIPLES OF PROGRAMMING WITH BUSINESS APPLICATIONS (3)
404. INFORMATION STRUCTURES (3)
410. INTRODUCTION TO COMPUTER SYSTEMS (3)
411. SYSTEMS ORGANIZATION AND PROGRAMMING (3)
420. THE STRUCTURE OF PROGRAMMING LANGUAGES (3)
430. COMBINATORICS AND GRAPH THEORY (3)
453. (Math. 453) NUMERICAL COMPUTATIONS (3)
454. (Math. 454) MATRIX COMPUTATIONS (3)
460. LOGIC AND COMPUTABILITY (3)
490. SPECIAL TOPICS IN COMPUTER SCIENCE (1-9)
491. COMPUTER PROJECTS (3)

500. THEORY OF AUTOMATA (3) Foundations of computer science with emphasi on computability; logic and structure of finite automata. Prerequisites: Cmp.Sc 401, 402, or 403; 3 credits in logic at the 400 level.

501. ALGEBRAIC THEORY OF AUTOMATA (3) Prerequisite: Cmp.Sc. 500.

510. STRUCTURE OF ARTIFICIAL LANGUAGES (3) Structure of problem-oriented languages; syntactical description, algorithms for translation, list structures, strin

manipulation, formula manipulation, relation to linguistics. Prerequisites: 3 credits in logic or logical design at the 400 level; Cmp.Sc. 401, 402, or 403.

511. Systems Programming (3) Interpretive systems; assemblers, loaders, compilers, library monitor systems; input-output scheduling; executive programs, job scheduling; multi-access systems, multiprogramming, multiprocessing. Prerequisite: Cmp.Sc. 410.

530. Nonarithmetic Programming (3) Combinatorial problems, learning mechanisms, heuristic programs, and pattern recognition. Prerequisite: Cmp.Sc. 401, 402, or 403.

540. Information Processing Systems (3) Data structures and data processing; information retrieval systems. Prerequisite: Cmp.Sc. 401, 402, or 403.

590. Seminar in Computer Science (1-3) Topics from current research.

591. Special Topics in Computer Science (2-6)

592. Special Topics in Foundations (2-6)

593. Special Topics in Languages and Systems (2-6)

594. Special Topics in Nonnumerical and Self-improving Systems (2-6)

COUNSELOR EDUCATION (CN ED)

Edwin L. Herr
In Charge of Graduate Programs in Counselor Education
115 Education and Psychology Center

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Herr, Hudson, Hylbert, and Wellington.
Graduate Faculty, Associate Members: Associate Professors Britton and Kelz.

Professional preparation is offered at the master's level for school counselors (elementary and secondary), college counselors, and rehabilitation counselors. Doctoral programs prepare candidates for positions of responsibility and leadership in these same areas. Doctoral candidates must have a minimum of one year's work experience in their field.

All candidates for graduate degrees in counselor education must present for admission at least 27 undergraduate credits in economics, education, psychology, sociology, and physiology or anatomy with some credits in at least three of these areas.

All candidates are expected to exhibit, in addition to academic competence, effectiveness in interpersonal relations and in both written and oral communication. They must also evidence support of professional counseling activities and organizations.

A candidate for either a Ph.D. or a D.Ed. must earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree, preferably at the thesis planning and writing stage.

COUNSELOR EDUCATION (CN ED)

412. Rehabilitation Facilities and Services of Pennsylvania (3)
413. Rehabilitation Case Recording and Management (3)

EDUCATIONAL SERVICES (ED SER)

403. Guidance Principles and Practices (3)
404. Teaching and Group Guidance About Occupations (3)
408. Introduction to Vocational Rehabilitation (3)
409. Medical Information for Counselors (3)
410. Rehabilitation of the Mentally Ill (3)

501. Counseling: Theory and Method (3) Theory and methods of counseling individuals whose problems of choice, decision, and adjustment fall within the normal range. Prerequisites: Ed.Ser. 506, Ed.Psy. 451.

503. Guidance Services in Elementary Education (3) Guidance services to elementary school students; guidance opportunities for elementary teachers and principals.

505. Occupational and Educational Information (3) Occupational information for guidance purposes; educational information related to vocational choice and preparation. Prerequisite: Ed.Ser. 403.

506. Student Analysis Procedures for Counselors (3) Collection and use of data basic to the counselor's understanding of individuals; the counseling interview and techniques other than testing.

507. Supervised Experience in Student Counseling (3) Practice in the application of guidance principles and methods to cases counseled under supervision; case conferences; seminar in guidance techniques. Prerequisite: Ed.Ser. 403.

508. Organization and Administration of Guidance Programs (3) Principles, organization, personnel, functions, integration with school programs, evaluation. Prerequisite: Ed.Ser. 403.

509. Contributions of Professional Personnel to Vocational Rehabilitation (3) Contributions of medical, social, psychological, and other specialists through the team approach; professional ethics, medical problems. Prerequisites: Ed.Ser. 403, 408.

511. Supervised Practicum in Rehabilitation Counseling (1-6) Application of principles and techniques of rehabilitation counseling to cases involving handicapped individuals. Prerequisites: Ed.Ser. 403, 408.

512. Professional Experience in Rehabilitation Counseling (1-6) Supervised internship with responsibility for a regular case load. Prerequisite: Ed.Ser. 511.

513. Supervision of Counselors (3-9) Practical experience in supervising and evaluating work of counselors. Prerequisite: Ed.Ser. 507.

DAIRY SCIENCE (D SC)

Donald V. Josephson, *Head of the Department*
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Almquist, Cone, Flipse, Josephson, Keeney, Kesler, Patton, and Watrous; Associate Professors Amann and McCarthy.
Graduate Faculty, Associate Members: Associate Professors Cloninger and Thoele.

Students may specialize in dairy products manufacture, chemistry of milk and dairy products, lipide metabolism, dairy cattle nutrition, dairy cattle genetics, dairy cattle management, and physiology of reproduction. The minor program is generally taken in biochemistry, microbiology, zoology, or agricultural economics.

Prerequisite to graduate work is the completion of an undergraduate major in animal industry, animal science, dairy science, food technology, or a related area. The undergraduate program must include college algebra and general physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiency work without degree credit.

DAIRY SCIENCE (D SC)

405. Dairy Cattle Management (3) *Mr. Cloninger*
418. Dairy Survey (1) *Mr. Josephson*
427. Milk Secretion (3) *Mr. Kesler*
428. Dairy Production Problems (1-6)
431. Physiology of Reproduction in Farm Animals (3) *Messrs. Almquist and Amann*

507. Dairy Cattle Management (1-6) *Mr. Kesler and Staff*

508. Dairy Seminar (1-6) Preparation and presentation of a paper on an assigned subject.

510. Dairy Cattle Feeding (1-6) Application of fundamental research in animal nutrition to the feeding of dairy cattle. Prerequisite: D.Sc. 1. *Mr. Kesler*

511. Dairy Cattle Nutrition (1-6) Nutritional requirements of dairy cattle. Prerequisite: A.Ntr. 401. *Mr. Kesler*

512. Advanced Studies in Milk Secretion (1-6) Physiology of milk secretion. Prerequisite: D.Sc. 427. *Mr. Kesler*

513. Dairy Cattle Breeding (1-6) Interpretation and application of current knowledge in genetics to dairy cattle breeding and selection. Prerequisites: An.Sc. 322, Biol. 422, 3 credits in statistics. *Mr. Thoele*

515. Advanced Physiology of Reproduction in Farm Animals (1-6) *Mr. Almquist*

516. Artificial Breeding of Farm Animals (1-6) Prerequisite: D.Sc. 431. *Mr. Almquist*

517. Dairy Science Literature (1-6) Review and reporting of dairy literature. *Mr. Josephson and Staff*

521. Dairy Radiophysiology (3) Metabolism and physiology of radioactive compounds; their use as tracers in animal physiology and the effects of radiation on metabolic processes. Prerequisite: Chem. 405. *Mr. Flipse*

Note: *See Animal Science and Food Technology under "Other Elective Graduate Courses."*

EARTH SCIENCES (EARTH)

E. Willard Miller
Chairman of the Committee on Earth Sciences
101 Mineral Sciences Building

Degree Conferred: M.Ed.

This program is designed to meet the needs of science teachers in secondary school The fields of study are astronomy, geography, geology, meteorology, and mineralog

The program prepares candidates to teach at least one field of the earth science familiarizes them with at least two additional earth science subjects, and at the sam time enables them to increase their competence in the physical sciences, the biologic sciences, and mathematics.

The student selects one of the earth sciences as an area of concentration, takes least 12 credits in it, and is required to write a term paper in that area. An addition 12 credits must be taken in at least two other fields of earth sciences, or in two ear science fields plus two courses selected from the biological sciences, chemistry, math matics, or physics. Furthermore, 6 credits in educational foundations are require as a minor.

The following courses offered by the various departments are appropriate for st dents majoring in earth and space science: Astro. 430; Geog. 490, 491; Geol. 40 401, 402; Gphys. 400; Meteo. 400, 401, 402, 403, 404; Min. 402.

ECONOMICS (ECON)

Grant N. Farr, *Head of the Department*
326 Boucke Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Budd, Coppock, Farr, Kaufman, Klei Levine, Mason, Newman, Prybyla, Reede, Robinson, Rozen, and Stout; Associate Pr fessor Myers.

Graduate Faculty, Associate Members: Associate Professors Herendeen, Riew, Saue lender, and Stromsdorfer; Assistant Professors Feller, Fox, and Hu.

Opportunities are available for concentration in the following fields: economic ana ysis, economic doctrines, economic development of developed areas, economic deve opment of underdeveloped areas, economic fluctuations, income distribution, industri organization, international economics, comparative economic systems, labor economic money and banking, public finance, quantitative economics, statistics, and region economics.

The department may waive the requirement of a thesis for M.A. candidates.

To enter graduate work in economics a student should have completed 6 credi in economic principles, 9 in the social sciences, and either 3 in statistics or 6 i mathematics. All applicants must take the Graduate Record Examination in advance economics and general aptitude.

ECONOMICS (ECON)

400. History of Economic Thought I (3)
401. History of Economic Thought II (3)

04. Current Economic Issues (3)
05. Advanced Economic Analysis (3)
12. Economics of Collective Bargaining (3)
13. Comparative Labor Movements (3)
14. (L.M.R. 414) Theories of the Labor Movement (3)
15. Social Insurance (3)
18. Economics of Wages and Employment (3)
19. Case Studies in Labor-Management Relations (3)
23. State and Local Taxation (3)
29. Advanced Public Finance (3)
33. International Monetary Economics (3)
42. Monopoly, Competition, and Their Regulation (3)
50. The Business Cycle (3)
51. Monetary Theory and Policy (3)
52. The Money Markets (3)
61. Economic Growth: Underdeveloped Areas (3)
62. Economic Growth: Theories of United States Development (3)
80. Mathematical Economics (3)
90. Introduction to Econometrics (3)
91. Analysis of Linear Economic Models (3)
99. Foreign Study in Economics (2-6)

00. Economics Seminar (3-6)

02. Microeconomic Analysis (3) Economic behavior under pure and imperfect competition; price and output determination in product markets; prices and employment in factor markets.

03. Macroeconomic Analysis (3) National income accounts; determination of income, employment, interest rates, and the price level; stabilization policy.

06. Problems in Economics (3-6) Planned individual projects involving library, laboratory, or field work.

07. International Trade (3) A survey of international trade theory including modern developments of pure theory, and of international trade policy.

08. Current Monetary Theory and Policy (3) Post-Keynesian reformulation of quantity and Keynesian theories of money; liquidity approach to monetary theory; current issues in theory and policy.

10. Econometrics (3-6) Statistical estimation in mathematically formulated economic relationships.

12. Wage Determination (3) Development of wage and employment theory; structure of labor markets; impact of unions on income distribution, price level, and employment.

13. Development of Economic Doctrines (3-6)

15. Economics of the Labor Market (3) Theory and problems of labor-management relations; selected problems of the labor market with reference to current research and developments.

16. Economics of Human Resources (3) Analysis of changes in human resource supply and demand; factors affecting these changes; current human resource policies.

17. International Finance (3) Problems of international liquidity; balance of payments adjustment; international financial institutions and selected policy problems.

518. Development of Monetary Theory (3) Classical and neoclassical quantity theories of money and contemporary criticism; Keynesian monetary theory and its critics.

521. Advanced Microeconomic Theory (3) Theory of consumer behavior; theory of the firm; price determination in product and factor markets; introduction to welfare economics.

522. Advanced Macroeconomic Theory (3) Measurement of income; theories of consumption, investment, and money holdings; static determination of income and employment; introduction to dynamic analysis.

524. Income Distribution (3) Measurement of inequality; ethical issues in income redistribution; measurement and determination of distributive shares; problem of poverty.

528. Advanced Economic Theory: Selected Topics (3) Treatment of topics in economic theory to meet needs of advanced students seeking intensive work in selected areas.

529. Public Finance (3) Contemporary problems in public finance; instruments of fiscal policy in the achievement of full employment, price stability, and economic development.

530. Regional Microeconomics (3) Theoretical and empirical analysis of industrial location as determined by costs, markets, and agglomeration effects.

531. Regional Macroeconomics (3) Aggregate regional trade flows; sources of regional economic data; techniques for measuring regional economic activity; long-run regional growth.

543. Industrial Organization and Public Policy (3) The structure of American industry; performance and behavior; public policies toward business.

550. Economic Fluctuations (3) Analysis of the various theories of economic fluctuations; their methodological premises.

551. Stabilization Policy (3) Description and analysis of the alternatives and issues in stabilization policy.

560. Seminar in Economic Growth: Underdeveloped Areas (3-6) Resources and institutions; quantitative measures; theories of economic growth in developing areas; developmental policies.

561. Seminar in Economic Growth: Developed Areas (3-6) Growth models; strategic factors in growth; quantification problems; public policy.

571. Comparative Economic Systems (3) Comparative analysis of alternative resource allocation principles; growth and performance of different economic systems; problems of decision-making and control.

572. Soviet and Other Centrally Planned Economies (3) Principles, structure, and performance of centrally planned economies with special emphasis on the Soviet Union.

580. Mathematical Economics (3) Mathematical development of static and dynamic economic models: partial and general equilibrium analysis; growth dynamics; mathematical programming. Prerequisite: Econ. 480.

595. Seminar in Econometric Theory (3-6) Advanced study in the theories and problems relevant to the application of statistical methods to economics. Prerequisites: 6 credits of Econ. 510 and Math. 409.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

WILLIAM R. CARRIKER, *Head of the Department of Special Education*
101 Education and Psychology Center

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Bliesmer, Carriker, French, Heilman, McDonald, and Siegenthaler; Associate Professors Frick, Regal, and Smith.

Graduate Faculty, Associate Members: Associate Professors Berlin and Haspiel, Assistant Professors Cardon and Cartwright.

Exceptional children are those who deviate so far from average in physical, intellectual, emotional, or social characteristics that they cannot profit adequately from the usual public school program. It is the purpose of this program to prepare teachers, researchers, administrators, and college and university teachers in the areas encompassing the education of the mentally retarded, gifted, emotionally maladjusted, neurologically impaired, or crippled. A multidisciplinary approach is emphasized.

Prerequisites for a master's program include: a valid teaching certificate and 10 credits (2 of which must be in a practicum) in the education of exceptional children.

Applicants for doctoral study shall show evidence of (1) having completed a master's degree with "A" quality grades on at least one third of the graduate courses and (2) attaining a minimum score of 500 on both portions of the Graduate Record Examination, or 50 on the Miller Analogies Test, or 35 on the Quantitative Educational Device.

EDUCATION OF EXCEPTIONAL CHILDREN (E E C)

400. INTRODUCTION TO EXCEPTIONAL CHILDREN (3)
401. EDUCATIONAL ADJUSTMENTS FOR EXCEPTIONAL CHILDREN (3)
403. CURRICULUM DEVELOPMENT FOR EXCEPTIONAL CHILDREN (2-6)
405. PRACTICUM IN THE EDUCATION OF EXCEPTIONAL CHILDREN (1-12)
410. THE MENTALLY RETARDED (3)
420. THE MENTALLY GIFTED (3)
440. (S.P.A. 440) SURVEY OF SPEECH AND HEARING DISORDERS (3)
444. (El.Ed. 444) READING DISABILITIES (2-3)
445. (El.Ed. 445, Sec.Ed. 445) TECHNIQUES IN REMEDIAL READING (2-6)
454. DIAGNOSIS OF EDUCATIONAL DISABILITIES (3)
470. THE EMOTIONALLY DISTURBED (3)
480. THE NEUROLOGICALLY IMPAIRED (3)

500. SEMINAR IN SPECIAL EDUCATION (1-6) Continuing series of professional seminars designed to provide a forum for discussion of current and classical research concerning exceptional children. Prerequisites: Ed.Psy. 400 and 6 credits in education of exceptional children.

501. ADMINISTRATION AND SUPERVISION OF EDUCATIONAL PROGRAMS FOR EXCEPTIONAL CHILDREN (2-3) Problems connected with the instituting and organizing of classes for atypical children; the legal phases, finances, teaching personnel, pupil personnel, housing, equipment, courses of study, curriculum, etc. Prerequisites: E.E.C. 401 and Ed.Ser. 480 or teaching or administrative or supervisory experience.

502. INTERNSHIP IN SPECIAL EDUCATION (2-10) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty. Prerequisite: E.E.C. 405 or teaching experience.

509. Problems, Projects, and Area Studies in Special Education (1-6) May not be used for thesis credit. Prerequisite: 12 graduate credits in special education.

510. Problems in the Education of the Mentally Retarded (2-4) Study of existing curriculums, instructional practices, educational programs; experimentation in curriculum building and materials construction. Prerequisites: teaching experience and E.E.C. 410.

520. Problems in the Education of the Mentally Gifted (2-4) Analysis of educational needs of mentally gifted; curriculum construction and curricular materials. Prerequisites: teaching experience and E.E.C. 420.

545. (S.P.A. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. (S.P.A. 546) Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

554. Psychological and Educational Evaluation of Exceptional Children (3) Administration and interpretation of individual tests other than the Stanford-Binet, WISC, and WAIS. Prerequisite: Psy. 559.

570. Problems in the Education of the Emotionally Disturbed (2-4) Prerequisite: E.E.C. 470.

580. Problems in the Education of the Neurologically Impaired (2-4) Prerequisite: E.E.C. 480.

EDUCATIONAL ADMINISTRATION (ED A)

Walter J. DeLacy and Frank W. Lutz
In Charge of Graduate Programs in Educational Administration
204 Education and Psychology Center

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Davison, DeLacy, Lutz, McAulay, Remaley, and Willower; Associate Professor Bosch.
Graduate Faculty, Associate Member: Associate Professor Kohl.

Professional preparation programs are offered at the master's and doctor's degree levels for elementary and secondary school personnel whose objectives are to become principals, supervisors, superintendents, state education department personnel, professors of educational administration, and/or researchers in educational administration.

Requirements for admission to a graduate program in educational administration include 18 approved undergraduate credits in education and psychology. Applicants for admission to the master's degree program are required to have had one year of teaching experience, or to be currently engaged in teaching. Two years of teaching experience are required for admission to the administrator certification and/or doctoral program.

Candidates for the D.Ed. and Ph.D. degrees are required to complete a minimum of three consecutive terms in residence.

From the time of initiation of a 600-level thesis research program, all doctoral candidates shall continuously register for a minimum of 2 credits per term until the

termination of the graduate program. Failure to register for doctoral thesis credits in any term, unless approved by the candidate's committee, shall be considered automatic withdrawal.

Although candidates are required to specialize in a field of professional education, they are also encouraged to acquire a general education in the social sciences, the behavioral sciences, and the humanistic foundations.

EDUCATIONAL SERVICES (ED SER)

450. Visual and Other Aids in Safety Education (3)
451. Teaching Traffic Safety and Automobile Operation (3)
452. Organization and Supervision in Safety Education (3)
460. Introduction to Adult Education (3)
480. Educational Administration (2-3)

565. Principles of School Supervision (2-3) Organization of supervision; planning the supervisory program; developing standards of teaching and learning; improvement of learning through tests and teacher rating. Prerequisites: 18 credits in education and 3 years' teaching experience.

566. The Elementary School Principal as Supervisor (2-3)

567. The Secondary School Principal as Supervisor (2-3) Improvement of instruction; improvement of teachers in service; evaluation of teaching procedures; methods of supervision; selection and use of textbooks. Prerequisite: 3 years' teaching experience.

568. The Elementary School Principal as Administrator (2-3) Duties of the elementary school principal in organizing and administering his school.

569. The Secondary School Principal as Administrator (2-4) Problems of schedule making, teachers' meetings, curriculum making and revision, organization of extracurricular and guidance programs. Prerequisite: teaching experience.

571. The Educational Plant (2-3) School plant needs in terms of school population and curriculums; the building survey, developing a plant program, the building site, plant utilization, operation and maintenance, heating and ventilation, equipment, school building costs and finance. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

572. Public Relations for School Administrators (2-3) School-community relationships; social structure, social change, and the schools; case studies of community-school problems. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

573. Public School Finance (2-3) Financing of public education in relation to organization and control; the conceptual basis for local financial administration; taxation, state and federal aid, school revenue, and money management. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

574. State and National Education Programs (2-3) Existing state and federal functions and relations to education; proposed programs. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience, and previous work in school administration.

575. Administration of Adult Education in the Public Schools (3) The organization of a program of adult education; its legal status, finances, selection of teachers, learning personnel, housing, and other administrative problems connected with adult education. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

576. Legal Aspects of School Administration (3) Legal bases for the organization and administration of school districts and schools; the powers, rights, privileges, and responsibilities of school corporations, school boards, administrators, and personnel; the law and fiscal policies; the course of study, textbooks; contracts; taxes; torts; records; agents; and the judicial decisions involved. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

578. Dynamic Factors in School Administration (2-3) Intraorganizational relationships; administration and the school as a social system; formal and informal organization. Prerequisite: Ed.Ser. 480 or teaching or administrative or supervisory experience.

579. Public School Business Administration (2-3) Business management applied to school management problems; budgeting, accounting, purchasing, insurance, school equipment, cafeteria management; transportation, salaries, personnel management, and auxiliary and coordinate agencies. Prerequisites: Ed.Ser. 480 or teaching or administrative or supervisory experience; Ed.Ser. 573.

580. Seminar in School Administration (1-6) Administrative theories applied to educational organizations. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

581. Educational Survey Techniques (2-3) Methods for appraisal of an educational program; planning for expansion, consolidation, or reduction of educational offerings. Prerequisites: Ed.Ser. 480, 6 credits in educational administration.

582. Internship in Administration and Supervision (1-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

591. Internship in Public School Research (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

596. Seminar in Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in education.

597. Workshop in Current Educational Problems (1-6) For administrators, supervisors, experienced elementary and secondary teachers, guidance workers; administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Education (1-6) Independent work in the study of topics in education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

EDUCATIONAL PSYCHOLOGY (ED PSY)

William Rabinowitz, *Head of the Department*
311 Education and Psychology Center

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors DiVesta, French, Lathrop, Mitzel, Rabinowitz, Thevaos, and Withall; Associate Professor Seibel; Mr. Greenhill.

Graduate Faculty, Associate Members: Associate Professors Impellitteri, Snyder, and Wodtke; Assistant Professor Weener.

Graduate work is offered in the general field of educational psychology. Students may specialize and do research in school learning, educational and psychological measurement, statistics and research design as applied to education, and the psychology of instructional systems. Other areas of study related to educational psychology, such as counseling and guidance, clinical psychology, and special education, are offered in other departments of the University.

Special facilities include a research design laboratory, a laboratory for computer-assisted instruction, a self-instruction media laboratory, facilities for film production and editing, and a closed-circuit television studio in Chambers Building used for both research and instruction. Facilities in other departments available to students majoring in educational psychology are the Nursery School, the Psychology Clinic, the Reading Center, the Special Education Center for Children, the Division of Instructional Services, and the Speech and Hearing Clinic. The Computation Center, with several computer systems, is available for use in graduate student research.

Requirements for admission include a broad undergraduate background including some college mathematics, a minimum junior-senior scholastic average of B, and a satisfactory scholastic aptitude rating on either the Graduate Record Examination or the Miller Analogies Test. Applicants with a master's degree will be required to show more than minimum success in graduate study, including at least one third of their graduate credits of "A" quality.

Doctoral degree requirements include a major emphasis in one of the above areas of educational psychology with minor emphasis in two related areas (one being in this department). Typically, the doctoral program of study would include at least one course in each of the following areas: research methods, educational and/or philosophical foundations, computer science, human learning, instructional media, measurement, social or industrial psychology, clinical psychology, experimental psychology, and developmental psychology.

EDUCATIONAL PSYCHOLOGY (ED PSY)

400. Statistical Interpretation of Educational Research (2)
406. Applied Parametric and Nonparametric Statistics in Education (3)
407. Regression and Correlation Methods for Educational Data (2)
421. Learning Processes in Relation to Educational Practices (3)
450. (Psy. 450) Principles of Measurement (3)
451. Appraisal and Interpretation of Standardized Group Tests (2)
475. Introduction to Educational Research (2)
476. Experimentation in Educational Psychology (3)

501. Current Topics in Educational Psychology (2-6) Study of the current literature in educational psychology with emphasis on historical and theoretical aspects of important areas of investigation. Prerequisites: Ed.Psy. 406, 450, and 421.

506. Advanced Techniques for Analyzing Educational Experiments (2) Advanced techniques for research in education; analysis of covariance; repeated measures; randomized block designs; Latin square; and other experimental arrangements. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

507. Multivariate Procedures in Educational Research (3) Introduction to matrix algebra, computer programming, multiple regression analysis, multiple and canonical correlation, multiple discriminant analysis, classification procedures, factor analysis. Prerequisites: Ed.Psy. 406 and 407, or Psy. 415.

512. Group Processes in the Classroom (2) Basic concepts and perspectives in the study of group processes; instructional group interaction; analysis of classroom behavior.

513. Individual and Group Differences (2) Historical and contemporary attempts to relate individual differences to important social and educational issues. Prerequisite: Ed.Psy. 400 or Psy. 15.

519. Psychological Foundations for College Teaching (2) Psychological, sociological, and organizational variables which influence college student behavior. Designed for graduate students who anticipate careers in college teaching.

520. Application of Learning Models to Classroom Practices (2) Probabilistic models of acquisition in complex human learning; assessment of learning in the classroom that is amenable to such analysis. Prerequisite: Ed.Psy. 421.

522. Concept Learning in the Schools (2) Study of theory and research related to concept formation and attainment with implications for instruction. Prerequisite: Ed.Psy. 421.

523. Problem Solving in the Schools (2) Examination of theory and research related to cognitive processes in problem solving with implications for educational practice. Prerequisite: Ed.Psy. 421.

524. Theories of Learning and Instruction (3) Study of major classical theories of learning and recent developments in learning and instructional theory. Prerequisite: Ed.Psy. 421.

530. Theory and Research in Programmed Learning (3) Research and trends in programmed learning; preparation of short programmed sequences for experimental analysis. Prerequisites: Ed.Psy. 450 and 421, or Psy. 404.

532. Survey of Media Research (3) Systematic study of media research in educational applications of television, still and motion pictures, graphic and simulated environments. Prerequisite: Ed.Psy. 400 or Psy. 415.

550. Design and Construction of Psychological Measures (3) Lecture-practicum involving planning, construction, administration, and analysis of a psychological test; lectures stress construct validity, item analysis, and predictive validity. Prerequisite: Ed.Psy. 450.

554. Theories of Psychological Measurement (2) Basic true-score and error models; their extensions to test reliability and test validity; problems of item analysis and weighting. Prerequisite: Ed.Psy. 450.

558. Scaling Educational and Psychological Measures (2) Unidimensional and multidimensional scaling models with emphasis on psychometric methods and brief attention to psychophysical methods. Prerequisite: Ed.Psy. 450.

575. Seminar in Educational Psychology (3-9) A seminar dealing with specific topics in educational psychology. Open to advanced students in the behavioral sciences.

591. Problems and Projects in Educational Psychology (1-6) Independent work on special topics.

ELECTRICAL ENGINEERING (E E)

Arthur H. Waynick, *Head of the Department*
118 Electrical Engineering East

Degrees Conferred: Ph.D., M.S.; M.Eng.

Graduate Faculty, Senior Members: Professors Cross, Ferraro, Hale, Holt, Lewis, Mentzer, Nisbet, Ross, Volz, and Waynick; Associate Professors Adams, Das, Etzweiler, Lachs, Lee, and Quinn.

Graduate Faculty, Associate Members: Assistant Professors Bishop, Bredeson, Laxpati, Magoulas, McMurtry, Robinson, and Seliga.

Course offerings and research facilities are available in the following areas: antennas, communications systems (conventional and laser), computers (including digital, analog, and network analyzer), control systems, energy conversion and distribution, electron devices, information theory, ionosphere research (geomagnetism and aeronomy), microwave theory and techniques, networks, plasmas and MHD, power system analysis, servomechanisms, and wave propagation. A bachelor's degree in engineering or science is required with courses in electrical circuits, fields, and electronics.

The M.Eng. degree is not offered on the University Park Campus.

ELECTRICAL ENGINEERING (E E)

401. Network Analysis for Technology Teachers (3)
402. Electronic Devices and Circuits for Technology Teachers, Part I (3)
403. Electronic Devices and Circuits for Technology Teachers, Part II (3)
404. Electromechanical Energy Conversion for Technology Teachers (3)
411. Principles of Electromagnetic Fields (3)
413. Linear Network Analysis (3)
417. System Theory (3)
419. Solid State Devices (3)
421a,b,c,d. Electrical Engineering Problems (1-10)
425. Symmetrical Components (3)
428. Linear Control Systems (3)
429. Control System Design (3)
432. Microwave Methods and Analysis (3)
435. Engineering Analysis (3)
437. Engineering Applications of Complex Variables (3)
438. Electromagnetic Theory and Radiating Systems (3)
441. Active Circuits (3)
448. Linear Electronic Design (3)
449. Digital Electronic Design (3)
450. Network Analysis (3)
459. Introduction to Statistical Theory of Communications (3)
461. Fundamentals of Power System Stability (3)
470. Electronic Analog Computers (3)
471. Logical Design of Switching Systems (3)
472. Introduction to Digital Computer Systems (3)
490. (Nuc.E. 490) Introduction to Plasma Theory (3)
491. Plasma Phenomena and Diagnostics Laboratory (3)

514. Quantum Electronics (3) Quantization of electromagnetic fields; quantum statistics of attenuators and amplifiers; analysis of laser oscillators; Glauber P-representation; photon detection and coherence. Prerequisite: Phys. 561.

520. Seminar (1) Required of all graduate students in electrical engineering. Conferences, reading, and presentation of technical papers.

521. Advanced Electrical Engineering Problems (1-10)

523. Nonlinear Analysis (3) Transient and steady state analysis of nonlinear physical systems; phase plane analysis, iterative techniques, singular points, and subharmonics. Prerequisite: E.E. 435.

525. Symmetrical Components (3) Polyphase circuits and machines under unbalanced conditions of operation including effects of rotating machines upon distribution and transmission system performance; characteristics of phase converters and single-phase operation of polyphase systems. Prerequisite: E.E. 425.

526. Semiconductor Electronics (3) Advanced semiconductor theory and applications to transistors and other semiconductor devices; modern semiconductor circuits. Prerequisite: E.E. 448.

527. Linear Control Systems (3) Continuous and discrete-time linear control systems; state variable models; analytical design for deterministic and random inputs; time-varying systems; system stability. Prerequisite: E.E. 428 or M.E. 455.

528. Nonlinear Control Systems (3) Design of nonlinear automatic control systems; numerical methods; phase-plane methods; describing functions; optimum switched systems; Liapunov and Popov stability. Prerequisite: E.E. 428 or M.E. 455.

529. Optimal Control (3) Variational methods in control system design; classical calculus of variations, dynamic programming, maximum principle; optimal digital control systems; state estimation. Prerequisite: E.E. 527.

530. Optimal Control (3) Minimum-time and minimum-fuel controls; generalizations of the maximum principle; computational methods in optimal control. Prerequisite: E.E. 529.

532. Ultra-High-Frequency Engineering (3) Theory of wave guides and discontinuities, resonant cavities, traveling wave oscillators and devices; interaction of fields with matter. Prerequisite: E.E. 432.

535. Engineering Analysis (3) Applications of mapping methods, series and integral representations to the solution of boundary value problems in electrical engineering. Prerequisite: E.E. 437.

536. Transform Methods in Linear Analysis (3) Analysis of linear systems by Laplace transform with emphasis on periodic nonsinusoidal forcing functions. Prerequisite: E.E. 435.

538. Electromagnetic Engineering (3) Electromagnetic fields using the Maxwell-Lorentz equations as applied to vector fields, special solutions to scattering, diffraction, and radiation problems. Prerequisite: E.E. 438.

550. Network Synthesis (3) Positive real functions, realizability conditions, synthesis of driving point immittances, synthesis of two-terminal pair networks, transfer function synthesis. Prerequisites: E.E. 437, 450.

560. Statistical Theory of Communications (3) Generalized harmonic analysis; the application of correlation and convolution to the detection of signals in noise; various special topics. Prerequisite: E.E. 459 or Math. 409.

561. Information Theory (3) Mathematical measurement of information: information transfer in discrete systems; redundancy, efficiency, and channel capacity, encoding systems. Prerequisite: E.E. 459 or Math. 409.

569. Simulation of Biomedical Systems (3) Simulation of biological and medical systems on analog and digital computers; direct electrical analogs; modeling techniques. Prerequisites: E.E. 470 or Cmp.Sc. 401 and Biol. 11.

570. Advanced Electronic Analog Computers (3) Advanced techniques of analog computation and simulation; machine and problem errors; nonlinear differential equations. Prerequisite: E.E. 470.

571. Digital Computers: Recent Developments and Advanced Logic (3) Advanced treatment of logical design; discussion of topics of current interest in the general area of digital computers. Prerequisite: E.E. 471.

580. Radio Waves and the Ionosphere (3) The magneto-ionic theory of ionospheric wave propagation; ray-optical approximations; determination of ionization profiles; full wave solutions; nonlinear and coupling effects. Prerequisite: E.E. 62 or 438 or Phys. 557.

581. Constitution of the Ionosphere (3) Properties of neutral and ionized atmosphere above 60 km; photochemical processes; solar, meteoric perturbations of the ionosphere; large-scale movements in ionization.

590. (Nuc.E. 590) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: E.E. 490.

591. (Nuc.E. 591) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: E.E. 590.

592. Engineering Magnetohydrodynamics (3) Fluid properties; derivation of MHD equations; channel flows; MHD waves; stability theory; power generation techniques. Prerequisite: E.E. 438.

ELEMENTARY EDUCATION (EL ED)

A. Madison Brewer, *Head of the Department*
150 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Bixby, Bliesmer, Brewer, Corle, Heilman, McAulay, and Riedesel; Associate Professors Bosch and Zafforoni.

Graduate Faculty, Associate Members: Professor Alessandro, Associate Professor Alfke.

The graduate programs provide advanced professional preparation for kindergarten teachers, elementary school teachers, and curriculum specialists. For admission 18 credits in elementary education and teaching experience are required.

ELEMENTARY EDUCATION (EL ED)

401. Training in Nature for Camp Counselors (3)
426. Problems of Elementary School Arithmetic (2-3)
433. Teaching Social Studies in the Elementary Grades (2-3)
436. Teaching of Conservation of Natural Resources in the Elementary School (3)
437. Teaching of Conservation of Natural Resources in the Elementary School (3)
438. Teaching Science in the Elementary School (1-3)
443. The Elementary School Reading Program (2-3)
444. (E.E.C. 444) Reading Disabilities (2-3)
445. (E.E.C. 445, Sec.Ed. 445) Techniques in Remedial Reading (2-6)
449. Teaching Children's Literature (2-3)

453. Special Problems in the Teaching of Elementary School English (2-3)
461. Elementary Education (2-3)
467. Advanced Theory of Kindergarten (3)
479. Measurement of Achievement in the Elementary School (2-3)
485. Workshop in Selected Studies in Elementary Education (1-6)

511. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education, including at least 5 in methods.

520. Internship in Elementary Education (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

526. Applications of Research in the Teaching of Elementary School Mathematics (3) Research applications dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of elementary school mathematics. Prerequisites: El.Ed. 426 and elementary teaching experience; Ed.Psy. 400.

533. Problems and Issues in Elementary School Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources, and promising proposals. Prerequisites: El.Ed. 433 and elementary school teaching experience.

546. (Sec.Ed. 546) Seminar on Reading Instruction (3-6) Research, procedures, and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: El.Ed. 443 or Sec.Ed. 443.

557. Reading Clinic Practice: Remedial Procedures (1-9) Practicum in special classes for reading disabilities; corrective and remedial procedures; specific procedures for correction of various types of reading disabilities. Prerequisite: El.Ed. 444.

559. Reading Clinic Research (1-15) Prerequisites: El.Ed. 443 or Sec.Ed. 443; El.Ed. 444.

562. Problems of Elementary Education (2-3) Problems seminar for experienced educators. Prerequisite: 12 credits in education and psychology, including 6 in elementary education.

563. Seminar in Contemporary Issues in Elementary Education (1-3) Conferences and discussions designed to meet the needs of experienced teachers and principals in the field of elementary education. Prerequisites: 6 credits in elementary education and teaching experience.

564. Organization of the Elementary School Curriculum (2-3) Principles underlying curriculum construction. Primarily for elementary education majors. Prerequisite: El.Ed. 311 or teaching experience.

585. Workshop in Current Elementary School Problems (1-6) For experienced elementary school teachers: administrative, supervisory, and instructional problems involved in an emerging educational program. Prerequisite: 12 credits of graduate work in education.

594. Seminar in Elementary Education (1-9) Conferences and discussions designed to meet the need for special study of particular fields in education. Prerequisite: 12 credits of graduate work in elementary education.

598. Problems, Projects, and Area Studies in Elementary Education (1-6) Independent work in the study of topics in elementary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

ENGINEERING ACOUSTICS (E ACS)

Richard O. Rowlands
Chairman of the Committee on Engineering Acoustics
227 Ordnance Research Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Brown, Johnson, Kendig, Rowlands, and Snowdon; Associate Professor Baker.

Graduate Faculty, Associate Members: Associate Professor Farwell, Mr. Boyd.

The aim of this program is to enable the student interested in acoustics to obtain an integrated program of courses covering the fundamentals of acoustical science and the biological, communications, and engineering applications of acoustics.

Programs are arranged through a selection of appropriate courses offered by the several departments of science, engineering, and arts, as well as those specifically in the area of engineering acoustics.

Areas of concentration include acoustic signal processing, architectural acoustics, noise and vibration, physical acoustics, speech and hearing, and underwater acoustics. Thesis research in the various areas may be conducted in relevant departments and in the Ordnance Research Laboratory.

Entering students should hold a bachelor's degree in physics, biology, engineering, architecture, mathematics, or speech and hearing, or in a closely related field; and they should have had at least one year of physics and mathematics including integral calculus. Course work should be so distributed that one area is covered in depth while a substantial number of courses are chosen from a combination of the other areas.

ENGINEERING ACOUSTICS (E ACS)

500. Special Problems in Acoustics (1-6) Provides training in selected areas of acoustics by means of supervised investigations or studies. Prerequisite: Phys. 443.

501. Engineering Acoustics Seminar (1 per term) Recent developments and current research in engineering acoustics.

511. Underwater Sound Propagation (4) Theoretical and empirical treatment of sound propagation in the ocean, including effects of the environment, characteristics of targets, and transducers.

512. Sonar Engineering (4) Theoretical and empirical treatment of problems related to the use of underwater sound in target detection and ranging.

513. Modern Acoustic Signal Processing (4) Probability review, representation of signals, noise processes, optimum filtering, ambiguity functions, linear and nonlinear signal processing, application to sonar systems.

514. Electroacoustic Transducers (4) The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media. Prerequisite: Phys. 443.

ENGINEERING MECHANICS (E MCH)

ROBERT M. HAYTHORNTHWAITE, *Head of the Department*
105 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Davids, Hardenbergh, Haythornthwaite, Hu, Jaunzemis, Neubert, Vierck, and Wislicenus; Associate Professor Sharma.
Graduate Faculty, Associate Members: Associate Professors Kiusalaas and Zamrik, Assistant Professor Hayek.

Graduate study is available in the following areas: (1) mechanics of rigid bodies including dynamics, vibration, and stress waves; (2) mechanics of deformable bodies including elasticity, plasticity, viscoelasticity, and continuum mechanics; (3) mechanics of materials and structures including mechanical properties, plates and shells, and plastic analysis; (4) experimental mechanics including experimental stress analysis, photoelasticity, and experimental vibration.

The entering student must hold a bachelor's degree in engineering or science and have satisfactorily completed undergraduate courses in mechanics.

ENGINEERING MECHANICS (E MCH)

400.	ADVANCED STRENGTH OF MATERIALS (3)	*Mr. Zamrik*
401.	ELEMENTS OF VIBRATIONS (3)	*Mr. Vierck*
402.	APPLIED AND EXPERIMENTAL STRESS ANALYSIS (3)	*Mr. Holister*
403.	MECHANICS OF THE SOLID STATE (4)	*Mr. Hu*
404.	RESEARCH IN ENGINEERING MECHANICS (1-6)	
407.	ELEMENTS OF COMPUTER METHODS IN ENGINEERING (3)	*Mr. Sharma*
408.	ELASTICITY AND ENGINEERING APPLICATIONS (3)	*Mr. Kiusalaas*
409.	ADVANCED MECHANICS (3)	*Mr. Hardenbergh*
410.	MECHANICS OF SPACE FLIGHT (3)	*Mr. Hardenbergh*
412.	EXPERIMENTAL METHODS IN VIBRATIONS (3)	*Mr. Neubert*
413.	PLASTIC ANALYSIS OF STRUCTURES (3)	*Mr. Hu*
414.	ELEMENTS OF MATERIAL SCIENCE (3)	*Mr. Queeney*
421.	CONTINUUM MECHANICS (3)	*Mr. Jaunzemis*
422.	CONTINUUM MECHANICS (3)	*Mr. Jaunzemis*
446.	MECHANICS OF VISCOELASTIC MATERIALS (3)	*Mr. Sharma*

500. ADVANCED MECHANICS OF MATERIALS (3-6) Strain energy methods; special problems in bending and torsion; curved bars, beams on elastic foundations; thick-walled cylinders, shrink-fit assemblies, and rotating discs; thin-walled pressure vessels; bending of thin plates; buckling of bars and plates. Prerequisite: E.Mch. 13.
Messrs. Kiusalaas and Sharma

506. EXPERIMENTAL STRESS ANALYSIS (3) Experimental methods of stress determination including photoelasticity, stress coat and electric strain gauge techniques; stress analogies; strain rosettes for combined stress determinations. Prerequisite: E.Mch. 408 or 507. *Mr. Holister*

507. THEORY OF ELASTICITY AND APPLICATIONS (3) Equations of equilibrium and compatibility; stresses and strains in beams, curved members, rotating discs, thick cylinders, torsion and structural members. Prerequisite: E.Mch. 13.
Messrs. Hu and Kiusalaas

508. THEORY OF ELASTIC STABILITY AND APPLICATIONS (3) Buckling of slender and short members; buckling of I-beams; stability of thin-walled constructions;

thin-walled cylinders subjected to internal pressures; applications to structural parts including aircraft members. Prerequisites: E.Mch. 12, 13. *Mr. Kiusalaas*

509. Theory of Plates and Shells (3) Bending and buckling of plates; elastic foundations; deformation of shells, multilayer shells, stress and stability analysis, weight optimization, application problems. Prerequisite: E.Mch. 13. *Mr. Kiusalaas*

514. Engineering Mechanics Seminar (1 per term) Current literature and special problems in engineering mechanics. *Mr. Davids*

516. Mathematical Theory of Elasticity (3) Fundamental equations and problems of elasticity theory; uniqueness theorems and variational principles; methods of stress functions and displacement potentials; applications. Prerequisite: E.Mch. 540. *Mr. Hayek*

520. Advanced Dynamics (3) Dynamics of a particle and of rigid bodies: Newtonian equations in moving coordinate systems; Lagrange's and Hamilton's equations of motion; special problems in vibrations and dynamics. Prerequisites: E.Mch. 12, Math. 72 or 431. *Messrs. Davids and Jaunzemis*

521. Stress Waves in Solids (3) Theoretical fundamentals, classic experiments; recent advances, including scabbing applications, plastic waves, penetration mechanics, impact, and numerical methods. Prerequisites: E.Mch. 12; Math. 405 or E.Mch. 524. *Mr. Davids*

522. Theory of Vibrations (3) Mathematical theory of vibrating systems; damping phenomena; forced vibrations; analogy between mechanical and electrical vibrations; transverse and torsional oscillation of shafts; vibration of strings, beams, membranes, and plates. Prerequisites: E.Mch. 13, Math. 72 or 431. *Messrs. Vierck and Neubert*

523. Computer Methods in Engineering Analysis (3) Finite elements, finite differences, and matrix methods applied to dynamics, elasticity, wave propagation, heat conduction, structural analysis, and fluid flow. Prerequisites: Cmp.Sc. 401, Math. 72. *Mr. Davids*

524. Mathematical Methods in Engineering (3 per unit) Prerequisite: A.M. 451 or E.E. 435 or M.E. 452. *Messrs. Davids and Hayek*

Unit A (3) Basic tools, including Fourier, Legendre, and other orthogonal series, special functions, Laplace transforms. Applications in mechanics and other fields. Prerequisite: Math. 73.

Unit B (3) Solution techniques for boundary-value problems in curvilinear coordinates, integral transforms, Green's functions, potentials, applications to diffusion, vibration, wave-propagation. Prerequisite: E.Mch. 524A or Math. 431.

526. Nonlinear Mechanics (3) Integral curves, singular points, self-sustained oscillations, stability problems, Hill's and Van der Pol's equation, mechanical and electrical applications. Prerequisite: E.Mch. 522. *Mr. Neubert*

528. Experimental Methods in Vibrations (3) Investigation of one or more degrees of freedom, free and forced mechanical vibrations, vibration properties of materials, nondestructive testing. Prerequisite: E.Mch. 401 or 522. *Mr. Neubert*

530. Solid State Mechanics (3) Relation between solid state physics and mechanics; mechanical properties for static, fatigue, creep, and impact conditions; high temperature properties; applications. Prerequisite: E.Mch. 14. *Messrs. Hu and Zamrik*

531. Theory of Plasticity and Applications (3) Yield condition; plastic stress-strain relations; theory of slip-line fields; applications to bending, torsion, axially symmetric bodies, metal processing. Prerequisite: E.Mch. 507. *Mr. Hu*

533. Determination of Mechanical Properties (3) Experimental methods for determining hardness, elastic constants, creep behavior, fatigue strength, plastic flow, and dynamic properties of metals. Prerequisite: E.Mch. 14 or 530. *Mr. Hu*

534. Photoelasticity (3) Analysis of polariscopes; isoclinics, isochromatics, and stress trajectories; two- and three-dimensional photoelastic methods; determination of principal stresses; model preparation. Prerequisite: E.Mch. 408 or 507. *Mr. Holister*

540. Introduction to Continuum Mechanics (3) Algebra and analysis of tensors; balance equations of classical physics; the linear theories of continuum mechanics. Prerequisite: E.Mch. 421. *Mr. Jaunzemis*

541. Nonlinear Theories of Continuum Mechanics (3) The general theory of constitutive equations; finite deformations and elasticity; flow and fluidity; viscoelasticity, modern topics. Prerequisite: E.Mch. 540. *Mr. Jaunzemis*

546. Theory of Viscoelasticity and Applications (3) Linear and nonlinear viscoelastic theories; generalized isotropic and anisotropic viscoelastic stress-strain relations. Prerequisite: E.Mch. 507. *Mr. Sharma*

550. Studies in Engineering Mechanics (1-6) Studies in any field of engineering mechanics.

570. Random Vibrations in Structural Mechanics (3) Probability theory applied to random vibrations of linear and nonlinear systems; excitation by ground motion, turbulence, and noise; acoustic damping. Prerequisite: Aersp. 411 or E.Mch. 401 or 522.

ENGINEERING SCIENCE (E SC)

Samuel S. Lestz
Chairman of the Engineering Graduate Committee for Off-Campus Programs
302 Mechanical Engineering Building

Degree Conferred: M.Eng.

A program leading to the degree of Master of Engineering with a major in engineering science is offered at the Behrend and King of Prussia Graduate Centers and at the Capitol Campus near Harrisburg. Details of the program may be obtained by writing directly to these locations. Addresses are given on the inside front cover.

The program is designed to provide a broad, advanced education in the engineering sciences with some specialization permitted in the area of a student's major interest. It is offered specifically to permit practicing engineers to pursue advanced studies through evening classes while in full-time employment in industry in the area. Courses offered for the program are all established and controlled by the resident departments at the University Park Campus.

The credit requirements in this major will be satisfied by an appropriate combination of core courses and elective courses. The core courses include offerings in mathematics and in several branches of engineering which have been selected because of their general character and breadth of applicability to all fields of engineering.

A minimum of 30 credits of course work is required, of which at least 12 must be at the 500 level. A scholarly written report is also required.

A bachelor's degree in engineering or a closely allied field is required for admission.

ENGLISH (ENGL)

HENRY W. SAMS, *Head of the Department*
245 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Bayard, Condee, Cramer, Davis, Euwema, Frank, Goldberg, Jewkes, Lewis, Meserole, Rubin, Sams, Sutherland, Weintraub, and Young; Associate Professors Bressler, Oldsey, Reed, Trachtenberg, Wellwarth, and West.

Graduate Faculty, Associate Members: Associate Professors Austin, Borklund, Gidez, and Hansen.

A student may specialize in English literature, American literature, philology, or rhetoric. It is preferred that an entering student present 24 credits in English, but 18 credits in English exclusive of survey and freshman courses will be accepted. If the student does not present 18 credits in English, he must make up the deficiency early in his graduate work.

A thesis is required of all M.A. candidates in this major.

ENGLISH (ENGL)

406. HISTORY OF THE ENGLISH LANGUAGE (3) *Messrs. Bell, Buckalew, and Shedd*
407. HISTORY OF THE ENGLISH LANGUAGE FOR TEACHERS (3) *Messrs. Bell, Buckalew, and Shedd*
408. ADVANCED COLLEGE GRAMMAR (3) *Miss McElwee*
411. PROBLEMS OF STYLE (3)
412. THE WRITING OF FICTION (3-6) *Messrs. Klass, Rogers, Rubinstein, and West*
413. VERSE WRITING (3-6) *Mr. Haag*
414. BIOGRAPHICAL WRITING (3) *Mr. Weintraub*
418. ADVANCED TECHNICAL WRITING AND EDITING (3-6) *Messrs. Damerst, Houp, and Marder*
422. MASTERS OF BRITISH LITERATURE (3-6)
423. HISTORY OF BRITISH LITERATURE (3) *Mr. Arnold*
424. MOVEMENTS IN BRITISH LITERATURE (3)
432. MASTERS OF AMERICAN LITERATURE (3-6) *Staff*
433. HISTORY OF AMERICAN LITERATURE (3) *Messrs. Sutherland and Gidez*
434. MOVEMENTS IN AMERICAN LITERATURE (3-6) *Staff*
435. THE AMERICAN SHORT STORY (3) *Mr. Bressler*
437. AMERICAN POETRY (3) *Messrs. Davis, Rubin, and Hansen*
438. AMERICAN DRAMA (3) *Mr. Wellwarth*
441. POETRY AND PROSE OF THE EARLY 17TH CENTURY (3) *Mr. Condee*
442. POETRY AND PROSE OF THE LATE 17TH CENTURY (3)
443. JACOBEAN AND CAROLINE DRAMA (3) *Messrs. Jewkes and Reed*
444. SHAKESPEARE (3) *Messrs. Arnold, Jewkes, and Reed*
445. CHAUCER (3) *Messrs. Frank, Shedd, and Bell*
446. MILTON (3) *Mr. Condee*
447. POETRY AND PROSE OF THE 16TH CENTURY (3) *Mr. Reed*
448. ENGLISH DRAMA BEFORE SHAKESPEARE (3) *Mr. Jewkes*
449. SHAKESPEARE (3) *Messrs. Arnold, Jewkes, and Reed*
451. POETRY AND PROSE OF THE EARLY 18TH CENTURY (3) *Mr. Fitzgerald*
452. POETRY AND PROSE OF THE LATE 18TH CENTURY (3) *Mr. Wilson*
455. THE NOVEL IN ENGLAND TO JANE AUSTEN (3)
458. THE DRAMA FROM DRYDEN TO SHERIDAN (3) *Mr. Rogers*
461. BRITISH NON-FICTIONAL PROSE OF THE 19TH CENTURY (3) *Miss Austin*

462. Wordsworth and Coleridge (3) *Mr. Cramer*
463. Byron, Shelley, and Keats (3) *Miss Austin*
465. Victorian Novel (3) *Miss Austin*
466. The American Novel to 1900 (3) *Messrs. Young and Oldsey*
467. Victorian Poetry (3) *Mr. Cramer*
470. Literature of the British Commonwealth (3) *Mr. Sutherland*
475. Modern British Fiction (3) *Messrs. Sutherland and West*
476. The American Novel Since 1900 (3) *Messrs. Young and Oldsey*
477. British and American Poetry of the 20th Century (3)
478. British and Irish Drama Since 1890 (3) *Mr. Weintraub*
481. History of English Literary Criticism (3) *Messrs. Bressler, Borklund, Gidez, and Mayberry*
488. (C.Lit. 488) Modern Continental Drama (3) *Messrs. Weintraub and Wellwarth*
490. Rhetorical Theory and Practice (3) *Mr. Bowman*
491. Literature for Teachers in Secondary Schools (3) *Mr. Bressler*
*498. English Institute (6-12)

501. Materials and Methods of Research (4) Materials and techniques of research in English and American literary history; form and content of theses. Required of all graduate students with an English major. *Messrs. Meserole and Mann*

521. Old English Language (3) An introduction to the main features of the Old English language; readings in simple Old English prose and poetry.

522. Old English Literature (3) A reading of the more important poetic works in Old English.

523. Wordsworth and Coleridge (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Mr. Cramer*

524. Byron and Shelley (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period.

525. Blake and Keats (3) Major and some minor works; the pertinent criticism and scholarship; aspects of the period. *Miss Austin*

526. Tennyson and Browning (3) *Mr. Cramer*

536. Henry James (3) The development of James as critic, novelist, and short story writer. *Mr. Borklund*

537. Robinson and Frost (3) The art and thought of two American poets who link the traditions of the 19th and 20th centuries. *Mr. Davis*

540. Studies in Elizabethan Prose and Poetry (3-6) *Mr. Reed*

541. Medieval Studies (3-6) Special problems in medieval English literature. *Mr. Frank*

542. Middle English Literature (3) Introduction to Middle English and its dialects; study of the literature of the period exclusive of Chaucer.

543. Studies in Early 17th Century Literature (3-6) Major poets and prose writers from 1600 to 1660. *Mr. Condee*

544. Restoration Literature (3) Selected studies of writers in England between 1650 and 1700.

* A maximum of 6 credits in one summer.

545. CHAUCER (3-6) Critical study of the *Canterbury Tales* or *Troilus and Criseyde* and minor poems. *Mr. Frank*

546. MILTON (3) The poetry and prose of John Milton. *Mr. Condee*

548. ELIZABETHAN AND JACOBEAN DRAMA (3-6) English drama from 1558 to 1642 exclusive of Shakespeare. *Mr. Jewkes*

549. SHAKESPEARE (3-6) Special problems of sources, chronology, text, characterization, and motivation in the drama. *Mr. Reed*

552. SWIFT AND POPE (3) *Mr. Sams*

553. THE AGE OF JOHNSON (3) The work of Johnson and his circle.

554. STUDIES IN EARLY AMERICAN LITERATURE (3) *Messrs. Meserole and Hansen*

555. THE PURITANS (3) Critical studies of the principal works of English and American Puritans. *Messrs. Meserole and Hansen*

556. EIGHTEENTH CENTURY BRITISH FICTION (3)

557. EARLY 18TH CENTURY BRITISH LITERATURE (3) Prose and poetry in the reign of Queen Anne, with special attention to periodical publications. *Mr. Sams*

560. AMERICAN ROMANTICISM (3) The Romantic movement in American literature of the mid-19th century. *Messrs. Davis and Trachtenberg*

561. STUDIES IN THE ROMANTIC MOVEMENT (3-6) *Miss Austin*

562. STUDIES IN THE LITERATURE OF VICTORIAN ENGLAND (3-6) *Mr. Cramer and Miss Austin*

564. STUDIES IN 19TH CENTURY AMERICAN LITERATURE (3) The major figures treated will vary from year to year. *Messrs. Rubin, Davis, and Hansen*

573. STUDIES IN 20TH CENTURY BRITISH LITERATURE (3-6) Major writers and literary movements. *Messrs. Weintraub and West*

574. STUDIES IN 20TH CENTURY AMERICAN LITERATURE (3-6) Major writers and literary movements. *Messrs. Young and Oldsey*

575. JAMES JOYCE (3-6) Alternate terms: *Ulysses* and *Finnegans Wake*. Knowledge of *Dubliners* and *A Portrait of the Artist* is assumed.

576. HEMINGWAY AND FAULKNER (3) The major works. *Messrs. Young and Oldsey*

578. SHAW (3) The plays, prose writings, and literary influence of G.B.S. *Mr. Weintraub*

579. T. S. ELIOT (3) Major works in poetry, criticism, and drama; pertinent scholarship and criticism. *Messrs. Lewis and Davis*

581. CONTEMPORARY LITERARY CRITICISM (3) *Messrs. Sams and Borklund*

582. HAWTHORNE AND MELVILLE (3) Detailed study of the major works of both authors and of the relationship between the two men. *Messrs. Young and Gidez*

583. EMERSON AND THOREAU (3) The significant prose and poetry of the chief American transcendentalists. *Mr. Bressler*

584. WHITMAN AND DICKINSON (3) The major texts, with special emphasis on background and language. *Messrs. Rubin and Davis*

585. Twain and Howells (3) The principal works, the relationship between the two men, and their place in American literature. *Messrs. Lewis and Oldsey*

587. Franklin and Edwards (3) Studies in the lives, works, and milieu. *Mr. Meserole*

590. Research Problems in British Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

591. Research Problems in American Literature (3-6) Methods of research, problems of bibliography, and evaluation of sources and materials.

592. Studies in American Literary Myth (3) An introduction to an interpretive, interdisciplinary study of some representative themes in American literature and culture. *Mr. Young*

593. Anglo-American Folk Song (3) Survey of relevant literary and ethnological scholarship and field work, European and American, from the early 16th century to the present. *Mr. Bayard*

595. Studies in British Fiction (3-6) *Messrs. Sutherland and Weintraub*

596. Studies in American Fiction (3-6) *Messrs. Trachtenberg and Gidez*

597. Studies in American Poetry (3-6) *Messrs. Rubin, Davis, and Hansen*

598. Readings in English (1-6) Programs of readings in English and American literature, designed to meet specific needs of individual students.

ENTOMOLOGY (ENT)

Beckford F. Coon, *Head of the Department*
204 Armsby Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Asquith, Coon, Frear, and Rutschky; Associate Professors Mumma, Smyth, and Snetsinger.
Graduate Faculty, Associate Members: Associate Professors Boyle, Ercegovich, and Yendol; Assistant Professors Benton and Kearby.

A student majoring in entomology may specialize in various areas of economic entomology and in forest entomology, apiculture, insect resistance in plants, arachnology, medical or veterinary entomology, biological control, insect transmission of plant pathogens, ecology, morphology, embryology, taxonomy, physiology, insect behavior, or chemistry of pesticides.

For admission a student is required to have 24 credits in entomology and related biological and physical sciences. Chemistry through organic, physics, mathematics, and statistics are advantageous. A limited deficiency may be made up, without degree credit, while pursuing graduate work.

ENTOMOLOGY (ENT)

401. Medical and Veterinary Entomology (3) *Mr. Rutschky*
402. Insect Ecology (3) *Mr. Kearby*

403. (Biol. 403) Systematics (3) *Mr. Boyle*
405. Insect Morphology (3) *Mr. Rutschky*
411. Insect Physiology (3) *Mr. Smyth*
413. Entomology Seminar (1 per term)
429. Insect Control (3) *Mr. Hower*
431. Special Problems (1-6)
435. Arachnology (3) *Mr. Snetsinger*

506. Immature Insects (3) The morphology and taxonomy of the immature stages of insects. Spring term, even years. *Mr. Rutschky*

520. Special Topics (1-6)

531. Insect Toxicology (2) General principles of toxicology and survey of the actions of substances toxic to insects. Fall term, odd years.

532. Insect Behavior (2) Orientation reflexes, learning, communication, and social behavior; physiological bases, ecological and evolutionary implications.

535. Biological Control (3) Practical and theoretical aspects of the biological control of arthropod pests. Spring term, even years. *Mr. Yendol*

540. Insect Resistance in Plants (2) Mechanism, expression, permanence, and measurement of resistance to insects with special reference to farm crops. Spring term, odd years. *Mr. Coon*

EXTENSION EDUCATION (EXT ED)

Emory J. Brown
Chairman of the Committee on Extension Education
204 Weaver Building

Degrees Conferred: M.Agr., M.Ed.

This program is designed primarily to meet the needs of professional teachers in various extension and adult education positions. The purpose is to train individuals to develop attitudes, understandings, and competencies which enable them to become more effective professional workers. Options have been developed for the Colleges of Agriculture and Human Development. Additional options will be offered as they are developed by other Colleges.

Admission requirements include a strong background in agriculture or home economics and a minimum of 12 credits in the social sciences.

For either degree a minimum of 30 credits is required, in addition to a professional paper. These credits should be distributed as follows: 12 credits in extension core courses, 6 in communication and/or education, and 12 in two areas of agriculture and/or home economics.

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

MARJORIE M. KNOLL
In Charge of Graduate Programs in Family Economics and Home Management
S-250 Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professor Knoll, Associate Professor Nichols.
Graduate Faculty, Associate Members: Associate Professors Gage and Van Dommelen, Assistant Professor Smith.

Those interested in emphasizing a study of home management, family economics, and family housing may do so through this major. There are no specific course requirements for admission.

The following courses are available in the area of family housing; their descriptions may be found under the offerings of Home Art: H.I. 401, 402, and 470 and F.H.H.Ar. 515, 530, 541.

In the graduate program family management practices, their effects upon members of the family unit, and the interaction of such practices with the local and national economy are studied in relation to principles of economics, philosophy, psychology, sociology, and political science.

CONSUMER SERVICES AND EQUIPMENT (CS EQ)

403. LECTURE-DEMONSTRATION TECHNIQUES (3)
413. HOME EQUIPMENT (3)
450. PROBLEMS IN HOUSEHOLD EQUIPMENT (1-6)

INDIVIDUAL AND FAMILY STUDIES (I F S)

416. (C.S. 416) CONSUMER ROLE OF FAMILY (3)
419. PROBLEMS OF FAMILY FINANCIAL MANAGEMENT (3)
424. ECONOMIC CONDITIONS IN RELATION TO THE FAMILY (3)
439. FAMILY RESOURCE MANAGEMENT (2)
442. HOME MANAGEMENT EXPERIENCE (3)
477. ANALYSIS OF FAMILY PROBLEMS (2-9)

FAMILY ECONOMICS AND HOME MANAGEMENT (FE HM)

515. CONSUMER PROBLEMS (2-3) Methods of securing, evaluating, and presenting data concerning household commodities. For home economics teachers in high schools, colleges, and adult classes.

524. ECONOMIC PROBLEMS OF THE HOUSEHOLD (3) Economic problems of the present-day family; special emphasis on factors in household production, use of money income, and standards of living.

528. HOME MANAGEMENT SUPERVISION (2-3) Evaluation of objectives and techniques in organization, supervision, and teaching of the home management house experience.

543. HOME MANAGEMENT IN RELATION TO FAMILY LIVING (3) Includes work with families in solution of their management problems.

44. Problems in Family Economics and Home Management (1-6) Investigation of selected problems in family economics and home management.

50. Seminar in Family Economics and Home Management (1-6) Discussion and reports on developments in family economics and home management.

FOOD SCIENCE (FD SC)

Donald V. Josephson
Chairman of the Division of Food Science and Industry
105 Borland Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Cone, Josephson, Keeney, Patton, and Watrous; Adjunct Professor Day; Associate Professors McArdle, McCarthy, and Sink; Adjunct Associate Professor Thompson; Assistant Professor Dimick.

Graduate Faculty, Associate Members: Associate Professors MacNeil and Ziegler.

Opportunities are available for study in the fields of dairy products, meats, fruits and vegetables, and poultry products. Special emphasis can be taken in food chemistry, microbiology, quality control, flavor control and acceptance, rheology of foods, processing, packaging, and distribution.

Prerequisite to graduate work is the completion of an undergraduate degree in food technology, biochemistry, microbiology, or other related area. The undergraduate program must have included college mathematics and physics. Students may be admitted with limited deficiency but are required to make up undergraduate deficiencies without degree credit.

FOOD TECHNOLOGY (FD T)

400. Effects of Processing on Food (3)
401. Sanitation and Quality Control (3)
402. The Thermal Process (1)
421. Technical Control Problems (1-10)

FOOD SCIENCE (FD SC)

510. Seminar in Food Science (1-6)

520. Problems in Food Science (1-9) Special problems in dairy, horticultural, meat, poultry, and other food products.

522. Research Procedures in Food Science (3) Research problems and methods in food science with major emphasis on food chemistry.

In addition to the courses listed above, the following courses are available in food science; their descriptions may be found under the offerings of the cooperating departments: A.I. 421, 431, 502; Ag.Eng. 406, 503; Bioch. 404; Hort. 528; Pty.Sc. 504.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

S. Earl Thompson
In Charge of Graduate Programs in Food Service and Housing Administration
4A Human Development Building

Degrees Conferred: M.S., M.Ed.

Graduate work in this field trains for management positions in institutions whic provide food service and housing to large groups, such as hospitals, residence hall children's homes, and other public and private organizations. For admission, a studer should have a baccalaureate degree in this or a related field.

FOOD SERVICE AND HOUSING ADMINISTRATION (FS HA)

402. Food Service and Housing Layout and Design (3)
410. Advanced Quantity Food Production (3)
425. Food and Labor Management and Control (3)
461. Personnel Functions in Food Service and Housing Administration (3
470. Problems in Food Service and Housing Administration (3)

502. Problems in Institution Administration (3-6) Individual study of prob lems in institution administration. Prerequisites: F.S.H.A. 310, 330.

FOODS AND NUTRITION (F N)

George P. Barron, Jr.
In Charge of Graduate Programs in Foods and Nutrition
202B Human Development Building

Degrees Conferred: Ph.D., D.Ed., M.S., and M.Ed. in Foods and Nutrition; M.S. i Nutrition in Public Health.

Graduate Faculty, Senior Members: Professors Barron and Pike, Associate Professo Cox.

Graduate programs in foods and nutrition prepare students for careers in colleg teaching, research, and adult program leadership. The program in nutrition in publi health prepares the student for work in public health agencies.

For admission to a graduate program in foods and nutrition, a student must hav completed at least 9 credits in organic and inorganic chemistry, 3 in biochemistry 3 in microbiology, 3 in physiology, 4 in other physical and biological sciences, an 8 in foods and nutrition.

For admission to the program in nutrition in public health, the requirements are a least 9 credits in organic and inorganic chemistry, 3 in biochemistry, 3 in micro biology, 12 in social sciences, 7 in foods, and 4 in nutrition.

NUTRITION (NUTR)

400. Special Problems in Foods and Nutrition (1-3)
420. Experimental Cookery (3)

121. Cultural and Aesthetic Aspects of Food (3)
122. Scientific Principles of Food Preparation (3)
152. Nutritional Aspects of Disease (3) *Miss Pike*
153. Diet Therapy (2)
156. Nutrition in the Community (3)
157. Principles of Nutrition (3) *Mr. Cox*
158. Applied Nutrition (2) *Mrs. Guthrie*
159. Advanced Nutrition (3) *Mr. Cox*
190. Foods and Nutrition Seminar (1)

FOODS AND NUTRITION (F N)

520. Readings in Foods (2) Critical review and reports of literature on selected food topics.

521. Seminar in Foods (1-6) Discussion and reports on current research in the foods field.

522. Advanced Experimental Foods (3) Experimental methods used in measuring the quality of foods; specific problems in food preparation.

530. Problems in Foods and Nutrition (1-6)

550. Readings in Nutrition (3) Readings and reports of selected topics in nutrition.

551. Seminar in Nutrition (1-6) Selected topics and recent advances in nutrition.

552. Nutrition in Disease (3) Physiological and biochemical problems in metabolic diseases and the nutritional aspects of therapy. *Miss Pike*

555. Field Work in Nutrition (2-4) Field problems planned to meet the needs of individual students. Hours and problems to be arranged. *Mr. Barron*

556. The Survey Method in Foods and Nutrition (2) Study of survey technique as a tool in the assay of food adequacy and nutritional status. *Mr. Barron*

557. Interrelationships of Nutrients (2) Interrelationships of nutrients in the metabolic processes; their significance as applied to nutrition. *Miss Pike*

FOREST RESOURCES (FOR R)

Wilber W. Ward
Director of the School of Forest Resources
101 Forestry Building

Degrees Conferred: Ph.D., M.S., M.F.

Graduate Faculty, Senior Members: Professors Fletcher, McDermott, Sopper, and Ward; Associate Professors George, Gerhold, Hutnik, Murphey, and Shipman.

Graduate Faculty, Associate Members: Professor Bartoo; Adjunct Associate Professor Lindzey; Assistant Professors Borden and Elers.

The graduate programs include two areas of technological inquiry, forest resource management and forest products; and two areas of scientific inquiry, forest science and wood science.

The technological area of forest resource management, which is concerned with planning and operation of the forest land complex, may include specialization in timber management, wildlife habitat management, watershed management, forest recreation, or a combination of all of these land use concepts within the framework of multiple objectives. An undergraduate degree in forest management or a similar program emphasizing biological science, economics, and applied mathematics provides the preparation necessary for these specializations.

The technological area of forest products is concerned with the application of wood technology to the forest products industries with possible specialization in industrial management, quality control, and marketing. An undergraduate degree in wood utilization or a similar program emphasizing mathematics and basic engineering courses is prerequisite.

The forest science area is concerned with those disciplines fundamental to forest management, including forest ecology, wildlife ecology, forest economics, forest entomology, forest genetics, forest hydrology, forest pathology, forest soils, tree physiology, mensuration, and silviculture. An undergraduate degree in forestry or a comparable degree emphasizing mathematics and biological, chemical, and physical sciences is prerequisite.

The wood science area is concerned with the fundamentals of the structural, physical, mechanical, and chemical properties of wood. The student may specialize in wood anatomy, wood moisture relations, wood chemistry, wood adhesion, wood engineering, and pathological and entomological considerations of wood products. An undergraduate degree in wood utilization or its equivalent in mathematics and biological and physical sciences is prerequisite.

FORESTRY (FOR)

403. Dendrology (3)
410. Forest Resources Seminar (1)
416. Forest Recreation (3)
421. Silviculture (3)
427. Forest Range Management (3)
440. Forest Economics and Finance (3)
450. Advanced Mensuration (3)
455. Forest Photo Interpretation (3)
466. Forest Resource Management (3)
469. (W.S. 469) Problems in Forestry and Wood Science (1-6 per term)
480. Policy and Administration (3)
492. Field and Laboratory Techniques in Wildlife Management in Fall (3)
493. Field and Laboratory Techniques in Wildlife Management in Winter (2)
494. Field and Laboratory Techniques in Wildlife Management in Spring (2)

504. (W.S. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

508. Advanced Forest Ecology (3) Organization, development, and classification of forest communities. Prerequisite: For. 308.

509. Wildlife Habitat Management (3) Management of forest associations for maintenance and development of wildlife. Prerequisite: For. 508 or Biol. 516.

510. Forestry Seminar (1 per term) Current problems of forest research presented as weekly seminar reports. May be repeated with additional credit for each term's work.

512. Forest Genetics (3) Theoretical and practical application of genetics to forestry; experiments in genetic variation, breeding, progeny testing, and vegetative propagation of trees. Prerequisite: Biol. 22.

517. Forest Microclimatology (3) Forest microclimatology quantitative treatment of climate near the ground, with special reference to the role of forests and terrain. Prerequisite: Phys. 202.

519. Forest Hydrology (3) Influence of forest cover on the disposition of precipitation and the application of hydrologic principles and techniques to forest watersheds. Prerequisites: For. 308, C.E. 51.

521. Advanced Silviculture (3) Specific silvicultural practices for the establishment and manipulation of forest stands with respect to recent developments and research needs. Prerequisite: For. 421.

525. Forest Land Use Alternatives (3) Recognition and analysis of various compatible and conflicting uses of forest land as a component of rural land. Prerequisites: For. 466, Ag.Ec. 421 or Geog. 405, 3 credits in statistics.

550. Design and Analysis of Experiments (3) Specialized techniques involved in the design and analysis of complex forestry research problems. Prerequisite: For. 450.

560. Timber Management (3) Technical methods in the organization and control of the forest property for timber production.

575. Applications of Forest Economics and Finance (3) Survey of situations in forestry where business problems and particular circumstances of production, value, and costs are currently significant. Prerequisite: For. 440.

WOOD SCIENCE (W S)

411. Physical Properties of Wood (3)
412. Mechanical Properties of Wood (3)
413. Chemical Properties of Wood (3)
420. Processing and Machining of Wood (2)
421. Adhesives and Finishes for Wood Products (2)
422. Seasoning and Preservation (2)
424. Commercial Tropical Woods (3)
430. Forest Products Manufacturing Systems and Standards (3)
437. Wood Micro-Technique (3)
462. Defects in Wood (3)
469. (For. 469) Problems in Forestry and Wood Science (1-6 per term)
491. Logging and Lumbering (3)
495. Forest Products Production Management (3)
497. Small Sawmills (3)

502. Wood Fibers (3) Identification and physical and chemical characteristics of wood fibers used for pulp, either for paper or as a source of cellulose; pulping quality, fiber measurements.

504. (For. 504) Special Topics in Forestry and Wood Utilization (1-6 per term) Problems in forest technology and forest sciences.

510. Wood Utilization Seminar (1 per term)

511. Wood-Fluid Relationships (3) Treatment of adsorption equations, thermodynamics, and diffusion through wood. Prerequisite: W.S. 337.

513. Wood Chemistry (3) Treatment of the chemical components of wood, their distribution and reactions. Prerequisite: W.S. 413.

531. Mechanical Behavior of Wood (3) Time-dependent properties, theory of failure, rheologic properties, and theory of the mechanical behavior of wood and structural composites.

532. Theory of Adhesion (3) Theory of adhesion as it pertains to bonding of wood, paper-based laminates, fibers, and bonding of wood to dissimilar materials.

595. Forest Products Industrial Operation Analysis (3) Applications of operations research methods in the forest products industry; mathematical programming, simulation, waiting line problems, sequencing. Prerequisite: W.S. 495.

FRENCH (FR)

Gérard J. Brault, *Head of the Department*
210 Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Belasco, Brault, Chapman, Eyer, Hyslop, and LeSage.
Graduate Faculty, Associate Member: Assistant Professor Knight.

The minimum requirement for admission to an advanced degree program will normally be 27 credits of post-intermediate work in language and literature. A student may follow a graduate program in French literature and in descriptive and historical linguistics with a minor in a related field. M.A. candidates may either submit a thesis or schedule 6 additional credits in 500-level courses in the major field.

FRENCH (FR)

417. French Phonology (3)
418. French Morphology and Syntax (3)
422. Old French Literature (3)
426. French Literature of the Renaissance (3)
435-436. 17th Century French Literature (3 each)
445. The Age of Enlightenment (3)
451-452. 19th Century French Literature (3 each)
460. French Prose of the 20th Century (3)
461. French Poetry and Drama of the 20th Century (3)
470. Advanced Composition and Conversation (3)
480. The Teaching of French (4)
*489. French Institute (7-14)
491. Problems in French Literature (3-6)
499. Foreign Study in French (3)

†1G. Elementary French for Graduate Students (3) Designed for students preparing to satisfy language requirements for advanced degrees.

* A maximum of 7 credits in one summer.
† No graduate credit is given for this course.

500. An Introduction to Old French (3) Analysis of the phonology, morphology, and syntax of the Old French language based on early literary monuments.

503. French Phonology (3) Articulatory and acoustic correlates of distinctive features; synchronic dialectology; phonology in generative grammar.

504. French Morphology and Syntax (3) Principles of segmentation and decomposition; tagmemics and transformation theory; morphophonemics.

505. Semantic Theory of the French Language (3) The goals of semantic description; systematic interrelation of semantic generalizations; empirical and methodological constraints.

516. The Song of Roland (3) Seminar in the Old French *Chanson de Roland,* with emphasis on the problems of textual criticism and literary analysis.

517. Villon (3) The poetry of Villon with reference to the cultural and social context of the late medieval period.

518. Medieval French Drama (3) The development of French drama from its liturgical origins to the flourishing comic theater of the late Middle Ages.

526. Rabelais (3) Seminar in works of François Rabelais, notably Book I (Pantagruel) and Book II (Gargantua), with emphasis on comic devices and narrative technique.

527. French Renaissance Poetry (3-6) Evaluation of French poetry from Marot through the Pléiade; emphasis on Ronsard and DuBellay.

528. Montaigne (3) Genesis and evolution of Montaigne's creation of the personal essay; influence of the *Essais* in 17th, 18th century French literature.

533. Seventeenth Century Prose and Poetry (3) The development of Classicism; its apogee and decline as seen in the works of major prose writers and poets.

534. Moliere (3) The literary achievement of Molière, the comic playwright, director, actor, and founder of the Comédie Française.

535. Seventeenth Century French Tragedy (3) The development and triumph of tragedy as a literary genre with special emphasis on the achievement of Corneille and Racine.

536. La Fontaine (3) The literary artistry of La Fontaine with special emphasis on his contribution as a fabulist.

540. Voltaire (3) The artistic and philosophical evolution of Voltaire as seen in the tragedy, the philosophical tale, and poetry.

541. Rousseau (3) Rousseau's rationalistic critique of civilization; his sentimental rehabilitation of the individual, family, state; Rousseau precursor of Romanticism.

542. Diderot and the Encyclopedists (3) The literary *philosophe* in the Age of Enlightenment with special emphasis on Diderot and his collaborators on the *Encyclopédie.*

561. French Romanticism (3) The Romantic movement in French literature with emphasis upon its major exponents in prose and poetry.

563. French Realism (3) The Realistic movement in French literature with emphasis upon its major exponents in prose and poetry.

565. The Nineteenth Century French Novel (3) The development of the novel in the 19th century with emphasis on Constant, Balzac, Stendhal, Flaubert, and Zola.

567. Twentieth Century French Theatre (3) Evolution of the French theatre from the plays of the *belle époque* to the avant-garde works of today.

568. Baudelaire (3) A study of his poetry and his criticism.

569. Masters of 20th Century French Literature (3-6) Major literary figures of contemporary French literature.

571. French Literary Criticism from Sainte-Beuve to Present (3) Evolution of French literary criticism from Sainte-Beuve, the "father" of modern literary criticism, to contemporary critics.

581. Theory and Techniques of Teaching French (1-3)

596. Symbolism (3) The anti-positivistic tradition in 19th century French literature dealing with the Symbolist School; its antecedents and its subsequent ramifications.

597. Research Techniques and Bibliography in French Language and Literature (1-3)

598. Seminar in French Literature (3-12) Lectures on methods of research. Students will pursue common and individual investigations in fields selected after consultation with the instructor.

FUEL SCIENCE (F SC)

Peter H. Given
In Charge of Graduate Programs in Fuel Science
316 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Essenhigh, Given, Palmer, and Walker; Associate Professor Vastola; Assistant Professor Polansky.
Graduate Faculty, Associate Members: Assistant Professors Becker and Roscoe.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree.

Research facilities, well instrumented, are available for the study of high temperature gas reactions by shock-tube and other techniques, electrochemical kinetics of fuel cell and battery systems, reactions in plasmas and flames, physics and chemistry of carbons and graphites, fundamental processes in the combustion of liquid and solid fuels, mass spectrometric investigation of the structure of solids, comminution of brittle materials, and the organic geochemistry of plant-derived sediments. Students can plan a wide variety of programs of study, to suit individual needs; coherent interdisciplinary programs are encouraged.

Students may be accepted with a B.S. or M.S. degree in chemistry; physics; chemical, aeronautical, or mechanical engineering, or fuel science.

A basic minimum of 30 course credits is required for the Ph.D. degree, of which at least 12 must be in departmental courses.

FUEL SCIENCE (F SC)

400. Fuel Science Research and Design (1-10 per term)
410. Fuel Science Laboratory (1) *Mr. Polansky and Staff*

411. Mathematical Modeling for Fuel Scientists (3)
421. Flames (3)
422. Combustion Engineering (3)
423. Combustion Laboratory (1)
424. Energy in Space Travel (3)
431. The Chemistry of Fuels (1)

504. (Gchem. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

506. Kinetics of Carbon Reactions (3) Current approaches to heterogeneous reactions in combustion and gasification of coals and carbons. Prerequisite: Chem. 451. *Mr. Walker*

510. Special Topics in Fuel Science (1-6 per term)

511. Fuel Science Seminar (1 per term) Selected topics from current research relevant to fuel science.

512. High Temperature Kinetics and Flame Propagation (3) Laminar and turbulent premixed and diffusion flames; gaseous detonations; rate processes in high temperature gases. Prerequisite: F.Sc. 421. *Mr. Palmer*

514. Jet and Rocket Fuels (2) Propulsion systems; combustion chamber conditions; liquid and solid propellants, slurries, fuel sprays, and finely divided solids. Prerequisite: F.Sc. 421. *Mr. Palmer*

515. Catalysis of Fuel Reactions (2) Principles of chemisorption and catalysis; mechanisms of specific catalytic reactions and practical aspects of catalytic processes in the fuels industries. Prerequisite: Chem. 452. *Mr. Walker*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in fuel science studies are listed under Mineral Sciences.*

GENERAL ENGINEERING (GEN E)

Otis E. Lancaster
Chairman of the Committee on General Engineering
101 Hammond Building

Degrees Conferred: M.Ed., M.Eng.

This program is designed primarily to meet the needs of the engineering faculty in the various technical institutes. The objective is to give academic preparation to those individuals who will teach engineering subjects at the two-year college level.

For admission an undergraduate degree in engineering, physical science, mathematics, or the equivalent is required.

For either degree a minimum of 30 credits is required in addition to a scholarly written report. Twenty-four of these credits should be in engineering, physics, and

mathematics. A candidate is expected to earn at least 3 credits each in mathematics, physics, and two fields of engineering, or demonstrate competence in them.

For the M.Ed. 6 credits must be in education, consisting of one 3-credit course in the theory of learning and teaching and one 3-credit course in internship in college teaching. Fifteen credits must be earned at the 500 level.

For the M.Eng. degree 6 credits may be taken in any field approved by the committee, but at least 12 credits in engineering subjects must be at the 500 level.

GENERAL FAMILY STUDIES (G F S)

ADDREEN NICHOLS
In Charge of Graduate Programs in General Family Studies
S-255 Human Development Building

Degrees Conferred: M.S., M.Ed.

Because this program is planned for teachers in secondary schools or small colleges and others who wish to become proficient in several areas of home economics, the student must have a strong home economics background for admission.

The major for the M.S. or M.Ed. degree consists of a minimum of 6 credits in each of three areas of home economics. The student chooses a minor field of educational foundations or, if sufficient competence in educational foundations is demonstrated, one of the applied fields, such as home economics education, secondary education, or higher education.

HUMAN DEVELOPMENT (H DEV)

400. SPECIAL PROBLEMS IN HUMAN DEVELOPMENT (1-6)

INDIVIDUAL AND FAMILY STUDIES (I F S)

410. COMMUNITIES AND FAMILIES (3)

GENERAL FAMILY STUDIES (G F S)

516, 516v. METHODS OF RESEARCH IN HOME ECONOMICS (3) Review of problems and techniques of research in home economics. Required of all graduate students in home economics.

GENETICS (GENET)

JAMES E. WRIGHT, *Chairman of the Committee on Genetics*
307 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Buss, Grun, Person, Thomas, Walker, Wright, and Zimmerman; Associate Professors Cleveland, Creech, Gerhold, Hicks, and Starling.

Graduate Faculty, Associate Members: Associate Professors M. W. Johnson and Pfeiffer; Adjunct Associate Professor Marshall; Assistant Professors Costantino and Craig; Adjunct Assistant Professor Hill.

Graduate programs are offered in the fields of theoretical and applied genetics, including plant and animal breeding. Courses in genetics and breeding are given by various departments. Basic and theoretical courses are offered in the Departments of Biology and Biophysics; courses dealing with genetic principles applied to specific organisms are offered in the Departments of Agronomy, Animal Science, Dairy Science, Forest Management, Horticulture, Microbiology, and Poultry Science. The graduate committee for majors shall be appropriately represented by members of theoretical and applied phases who have the responsibility and jurisdiction for determining course work, language requirements, and research acceptable in satisfying degree requirements.

For entry as a major in this field no fewer than 15 credits in basic biology and 15 credits in the areas of chemistry, mathematics, and physics are required.

The following courses are available in genetics or breeding, and their descriptions may be found under the offerings of the several departments: Agro. 411, 509, 510, 582; A.I. 501, 505; An.Sc. 422; Biol. 405, 422, 505, 524, 528, 533; Bphys. 410; D.Sc. 513; For. 512; Hort. 407, 444, 501, 514, 520, 524; Micrb. 516; Pty.Sc. 402, 505.

GEOCHEMISTRY (GCHEM)

Arnulf Muan
Head of the Department of Geochemistry and Mineralogy
204 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Barnes, Bates, Brindley, Burnham, Greig, Griffiths, Keith, Muan, Osborn, Roy, Wickman, and Wright; Associate Professors Dachille, Newnham, Suhr, Thornton, Weber, and White; Mrs. Roy.

Graduate Faculty, Associate Member: Associate Professor Rose.

Areas of specialization include crystal chemistry, phase equilibria, element distribution and affiliations, isotope geochemistry, geochemical prospecting, cosmochemistry, high-temperature and high-pressure geochemistry, and solid state technology.

Before starting graduate study, an applicant is generally expected to have had a standard introductory course in each of the following four subjects—chemistry, physics, geology, and mineralogy; 12 credits of intermediate-level work in any one or a combination of chemistry, physics, and geological science; and mathematics through integral calculus.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOCHEMISTRY (GCHEM)

402. Introduction to Organic Geochemistry (3)
457. Geochemical Prospecting (2) *Mr. Barnes*

501. Research (1-10 per term) Research in geochemistry.

504. (F.Sc. 504) Organic Geochemistry of Coal (3) Interdisciplinary study of accumulation of organic sediments and their metamorphism into coal macerals; effects of environment; structure of coal macerals.

509. Geochemistry Seminar (1 per term)

510. Problems in Geochemistry (1-9) Laboratory and library study of special problems.

512. Crystal Chemistry of Nonmetallic and Defect Solids (2-4) Relation of structure to ionic size, charge, polarizability; influence of p-t environment; chemical-structural defects, diffusion, transitions, and reactions in solids. *Mr. Roy*

513. Phase Equilibria in Mineral Systems at High Temperatures (2-4) Interpretation of phase diagrams with emphasis on high-temperature oxide systems at atmospheric pressure; measurement of p-t-x, determination of equilibrium diagrams.

514. Element Distribution in the Earth (3) Principles and data from studies of phase equilibria, petrology, and crystal structure as related to distribution of elements in minerals, rocks, and the earth. *Mr. Weber*

517. Age Determinations (1-2) Geochemistry of radioactive elements and their daughters; age determination techniques and observations. *Mr. Deines*

518. Stable Isotope Geochemistry (3) Theory of isotope fractionation mechanisms; its application to a wide range of problems in the earth and planetary sciences. *Mr. Weber*

519. Cosmochemistry and Nucleogenesis (2) Distribution and composition of matter; origin of solar system and earth, of constituent nuclides, of life.

520. P-T-X Phase Relations in Mineral Systems (2) Phase equilibrium in mineral systems with pressure as a variable. Prerequisite: Gchem. 513. *Mr. White*

522. Geochemistry of Aqueous Systems (3) Ionic and molecular equilibria related to stabilities and solubilities of minerals: Eh-pH, P_{O_2}-pH relations applied to ground water, sea water, hydrothermal fluids. *Messrs. Barnes and Schmalz*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geochemical studies are listed under Mineral Sciences.*

GEOGRAPHY (GEOG)

Allan L. Rodgers, *Head of the Department*
403 Deike Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Deasy, Gould, Lewis, Miller, Rodgers, Wernstedt, and Zelinsky.
Graduate Faculty, Associate Members: Associate Professor Simkins, Assistant Professor Adams.

The student may concentrate on economic geography, cultural geography, physical geography, one of the major world regions, or acceptable combinations of these

ields. In addition, all students receive training in cartographic, statistical, and bibliographic techniques.

Because physical geography is a branch of the physical sciences, and cultural and economic geography are branches of the social sciences, a student may enter graduate work under either of two options. Option 1, for the student who wishes to specialize in physical geography, requires the completion of 18 undergraduate credits in geography and 20 credits in mathematics and biological and physical sciences, including at least 6 credits in geology. Option 2, for the student who wishes to specialize in cultural or economic geography, requires 18 undergraduate credits in geography plus 20 credits in the social sciences, including at least 6 in economics.

GEOGRAPHY (GEOG)

401. Historical Geography of North America (3) *Mr. Zelinsky*
402. Cultural and Anthropo-Geography (3) *Mr. Zelinsky*
405. Geography of Population (3) *Mr. Zelinsky or Mr. Simkins*
407. Geography of Settlement (3) *Mr. Williams*
410. Cartography—Map Design and Construction (3) *Mr. Deasy*
420. Urban Geography (3) *Mr. Adams*
427. Geography of the Soviet Union (3) *Mr. Rodgers*
428. Geography of Eastern Europe (3)
430. Agricultural Geography (3)
433. Regional Climatology (3) *Mr. Wernstedt*
434. Regional Physiography (3) *Mr. Lewis*
440. Geography of Middle America (3) *Mr. Simkins*
441. Geography of South America (3) *Mr. Simkins*
442. Geography of Europe (3) *Mr. Miller*
443. Geography of the Orient (3)
444. Geography of Africa (3) *Mr. Gould*
445. Geography of Southern Asia (3) *Mr. Wernstedt*
446. Regional Geography of North America (3) *Mr. Gould*
451. Map Interpretation (3) *Mr. Lewis*
452. Interpretation of Aerial Photographs (3) *Mr. Deasy*
456. Quantitative Methods of Geographical Analysis (3) *Mr. Gould or Mr. Williams*
460. Political Geography (3) *Mr. Lewis*
468. Geography of Transportation and Communications (3) *Mr. Gould*
470. Industrial Location and Development (3) *Mr. Rodgers*
480. Geography of Manufacturing (3) *Mr. Miller or Mr. Rodgers*
490. Physical Geography for Teachers: Landforms (3) *Mr. Lewis*
491. Physical Geography for Teachers: Regional Climatology (3) *Mr. Wernstedt*

500. Introduction to Geographic Research (3)

501. Geographic Bibliography (1) An introduction to the techniques of bibliographic search and the writing of research papers in geography. Prerequisite: Geog. 500.

503. Advanced Regional Geography (3-12) Intensive study at an advanced level of selected regions or sections of the continents. Prerequisite: 12 credits in geography.

504. Physical Geography Seminar (3-12) The literature of some phase of physical geography with emphasis on procedures for organizing material for classroom reports and discussions.

505. Economic Geography Seminar (3-12) The literature of some phase of economic geography with emphasis on procedures for organizing material for classroom reports and discussions.

506. Political Geography Seminar (3-6) The exploration of current problems and theory in political geography through critical discussion of the literature and original student research. Prerequisite: Geog. 460.

507. Development of Geographic Thought (1-6) Critical analysis of the growth of geographic thought from antiquity to the present; emphasis on structure of modern geography.

508. Cultural Geography Seminar (3-6) The exploration of current problems and theory in cultural geography through critical discussion of the literature and original student research.

509. Population Geography Seminar (3) Selected problems in population geography with emphasis on analysis and presentation of data. Prerequisite: Geog. 405.

510. Physical Geography Research (3-10) Original study in physical geography: a field problem or detailed library investigation with analysis and presentation of data.

511. Economic Geography Research (3-10) Original study in economic geography: a field problem or detailed library investigation with analysis and presentation of data.

512. Cultural and Political Geography Research (3-10) Original study in cultural and political geography: a field problem or detailed library investigation with analysis and presentation of data.

543. Conceptual Frameworks for Geographical Analysis (3) Critical analysis of structures of inquiry in geography: modeling, problems of causation, measurement, and ordering of spatial information.

567. Applied Quantitative Methods (3) Simulation, topological, queuing, programming, factor analytic, discriminant, and game theoretic models applied to geographic problems of spatial diffusion and interaction. Prerequisite: Geog. 456.

GEOLOGY (GEOL)

Lauren A. Wright
Head of the Department of Geology and Geophysics
303 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Lattman, Ridge, Scholten, Spackman, Williams, and Wright; Associate Professors Dutcher, Schmalz, and Traverse.

Graduate Faculty, Associate Members: Associate Professors Gold and Parizek; Assistant Professors Cuffey, Guber, and Voight.

Students may specialize in stratigraphy, paleontology, paleobotany, palynology, regional and structural geology, geomorphology, ground water geology, marine geology

nd chemical oceanography, coal geology, coal petrology, and geology of metallic and onmetallic deposits.

Prerequisites for admission include 25 credits in an approved combination of hemistry, physics, mathematics, and biological sciences, and at least 18 credits in eology and mineralogy.

Students who have taken somewhat less than the indicated minimum in these ubjects may be admitted but must make up their deficiencies concurrently with heir graduate studies.

EOLOGY (GEOL)

400.	Surface Geological Processes for Teachers (3)	
401.	Earth History for Teachers (3)	*Mr. Cuffey*
402.	Field Methods for Teachers (3)	*Mr. Wright*
410.	Structural Geology (3)	*Mr. Gold*
420.	(Biol. 420) Paleobotany (3)	*Mr. Spackman*
421.	Introduction to Coal Petrology (3)	*Mr. Williams*
423.	(Biol. 423) Introductory Palynology (3)	*Mr. Traverse*
430.	Paleontology (3)	*Mr. Guber*
440.	Marine Geology (3)	*Mr. Schmalz*
451.	Economic Geology (3)	*Mr. Ridge*
452.	Introduction to Hydrogeology (3)	*Mr. Parizek*
453.	Mechanics of Geological Materials (3)	*Mr. Voight*
461.	Geology of North America (3-6)	*Mr. Wright*
462.	Principles of Geomorphology (3-6)	*Mr. Lattman*
470.	Introduction to Field Geology (3)	*Mr. Wright*
472.	Field Geology (5)	*Mr. Dutcher*
481.	Geology of Oil and Gas (3)	*Mr. Scholten*
490.	Stratigraphy (4)	*Mr. Williams*

*500. Geology Seminar (1-9) Presentation, at weekly departmental meetings, of topics selected from geological literature.

†501. Stratigraphy (3-12) Principles of stratigraphic classification, lithofacies and biofacies, faunal zonation, correlation, sedimentation, and paleogeography, illustrated by stratigraphy of classical geologic regions: (a) Pre-Cambrian; (b) Paleozoic; (c) Mesozoic; (d) Cenozoic. Prerequisite: Geol. 430. *Mr. Williams*

†503. Paleontology (3-9) Morphology of animal groups significant for their fossils; nature of species and faunal zones. Seminars may be arranged for studies of special fossil groups, microfossils, paleoecology. *Mr. Cuffey*

504. History and Foundations of Geology (2-4) Theoretical aspects of geology; spatio-temporal organization of matter, dynamic processes, sequential development; basic patterns and history of scientific thought. *Mr. Williams*

507. Seminar in Geomorphology (3-6) Classic and current literature in geomorphology. *Mr. Lattman*

511. Ore Deposits: Principles (3-6) Geological and geochemical processes controlling ore deposition; genetic classification of ore deposits. Prerequisite: Geol. 451. *Mr. Ridge*

512. Ore Deposits: Types (1-6) Geologic history and field examination of selected ore bodies; forming media; causes, sequences, and loci of emplacement; wall rock alteration; secondary enrichment. Prerequisite: Geol. 511. *Mr. Ridge*

* Credits to be arranged, 1 to 6 per term.
† Credits to be arranged, 3 to 6 per term.

515. Ore Microscopy (2-3) Theory and use of the ore microscope in identifying ore minerals in polished section, establishing paragenetic sequences, determining manner of deposition. *Mr. Barnes*

‡517. Sediments of the World (2-6) Evolution of sediments from Archean to Recent; relationship of sedimentation to geotectonism; kratonic and geosynclinal sediments; cyclicity. Prerequisites: Min. 512, 514. *Mr. Williams*

524. Coal Petrology (1-6) Microscopy, source materials, coalification, constitution, classification of peats, lignites, bituminous coal, anthracite. *Messrs. Dutcher and Spackman*

526. (Biol. 526) Problems in Palynology (1-6) Systematics; paleoecological palynology; Paleozoic palynology; Mesozoic and Cenozoic palynology; Pleistocene vegetational history. *Mr. Traverse*

530. Geological Problems (1-15) Prerequisite: 10 credits in geology and mineralogy.

540. Chemical Oceanography (3) Chemical reactions in sea water and at the sea floor related to sedimentation and diagenesis. *Mr. Schmalz*

545. Glacial Geology (3) Glaciers: their characteristics, causes, deposits, landforms, effects in periglacial regions. *Mr. Parizek*

546. Principles of Photogeology (3) Use of aerial photographs and mosaics in structural, geomorphic, and rock distribution studies and in compilation of maps. Prerequisites: Geol. 410, 462. *Mr. Lattman*

551. Dynamic Structural Geology and Geotectonics (3-6) Phenomena of fracturing, faulting, folding; stress and (finite) strain analysis, physical and analytical models; deformational environments; tectogenesis and orogenesis. *Mr. Scholten*

555. Advanced Structure and Petrofabrics (1-3) Macroscopic and microscopic recognition, measurement, and interpretation of small-scale rock structures and mineral orientation patterns in deformed rocks. *Mr. Gold*

571. Habitat of Oil (3) Geologic setting of petroleum as determined by basin tectonism, sedimentation, hydraulic and capillary forces, and reservoir textures. *Mr. Scholten*

590. Geology Field Trip (1 per year) Field study of regional geologic features with trips in successive years to differing geologic provinces.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geological studies are listed under Mineral Sciences.*

GEOPHYSICS (GPHYS)

Lauren A. Wright
Head of the Department of Geology and Geophysics
303 Deike Building

Degrees Conferred: Ph.D., M.S.

‡ Credits to be arranged, 2-3 per term.

Graduate Faculty, Senior Members: Professors Bell and Howell.
Graduate Faculty, Associate Members: Associate Professor Alexander, Assistant Professor Lavin.

Students may specialize in geophysical surveying, seismology, time-series analyses, geomagnetism, gravity, space applications of geophysics, tectonics, physical properties of rocks, radioactive age determinations, earth physics, and planetary sciences.

For admission an applicant is generally expected to have had mathematics through differential equations; a standard introductory course each in physics, chemistry, and earth sciences; and at least 16 credits of intermediate-level work in any one or a combination of these subjects.

Students may be accepted with a B.S. or M.S. degree in geophysics, physics, mathematics, engineering, earth sciences, or a closely allied field.

Students who have taken somewhat less than the indicated minimum in these subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

GEOPHYSICS (GPHYS)

400. Physics of the Earth for Teachers (3)
406. Physics of the Earth (3) *Mr. Howell*
407. Well Logging (3)
408. Geophysical Surveying (3) *Mr. Lavin*
415. Gravity and Magnetic Surveying (3) *Mr. Lavin*
416. Electrical Surveying (3) *Mr. Greenfield*
417. Seismic Methods (3) *Mr. Lavin*
418. Potential Theory Applied to Earth Problems (3) *Mr. Alexander*

500. Geophysical Seminar (1 per term) Discussion of geophysical reports and papers; scientific outlook.

501. Research (1-10 per term) Research in geophysics.

502. Seismic Instruments (3) Characteristics and design of seismometers and seismic recorders. *Mr. Howell*

503. Special Studies in Geophysics (1-9) Special studies of the theories of geophysical methods.

504. Communication Theory for Geophysicists (3) Basic theory of random processes leading to and including optimum filters; geophysical applications to gravity and seismic data analysis.

507. Seismology (3) Nature and transmission of seismic waves; cause and occurrence of earthquakes; applications in seismic prospecting. *Mr. Alexander*

508. Tectonics (3) Seminar in the cause and nature of the principal deformations of the earth.

516. Introduction to Nuclear Processes in Geologic Settings (2) Natural radioactivity and its measurement, interpretation, and use in research and exploration. *Mr. H. D. Wright*

521. Thermal State of the Earth (2) Methods and instrumentation of geothermal measurements; geothermal observations; development of the theory of the thermal state of the earth.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in geophysical studies are listed under Mineral Sciences.*

GERMAN (GER)

STANLEY R. TOWNSEND, *Head of the Department*
105 Burrowes Building

Degrees Conferred: Ph.D., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Ebbinghaus, Shelley, Strelka, and Townsend.

Graduate Faculty, Associate Members: Professor de Levie, Assistant Professor Kopp.

There is opportunity for major emphasis upon either literature or philology. Minimum qualifications for admission include 24 undergraduate credits in German beyond the intermediate level; provision is made, however, for admission with limited deficiencies.

Students may qualify for the M.A. and M.Ed. degrees either by writing a thesis—which is recommended if a student wishes to be considered for Ph.D. candidacy—or by submitting an essay to the department and taking additional 500-level German courses in lieu of 6 credits of thesis research.

GERMAN (GER)

401. ADVANCED STYLISTICS (3)
430. HISTORY OF THE GERMAN LANGUAGE (3)
443. (C.Lit. 443) LITERARY RELATIONS OF GERMANY WITH ENGLAND AND AMERICA (3-9)
454. LITERATURE FROM THE AGE OF CHIVALRY TO THE THIRTY YEARS' WAR (3)
464. LITERATURE FROM THE BEGINNING OF THE ENLIGHTENMENT THROUGH STORM AND STRESS (3)
469. GOETHE'S LIFE AND WORKS (3)
474. CLASSICISM AND ROMANTICISM (3)
484. LITERATURE FROM REALISM TO EXPRESSIONISM (3)

*1G. ELEMENTARY GERMAN FOR GRADUATE STUDENTS (3) Designed for students preparing to satisfy language requirements for advanced degrees.

*2G. ELEMENTARY GERMAN FOR GRADUATE STUDENTS (3) Continuation of Ger. 1G with opportunity for reading in special fields.

500. BIBLIOGRAPHY AND RESEARCH TECHNIQUES (3) Introduction to tools and methods of research, designed for students preparing for independent investigation of problems in German literature and language.

520. INTRODUCTION TO MIDDLE HIGH GERMAN (3) Descriptive and historical grammar; readings in simple Middle High German texts.

521. READINGS IN MIDDLE HIGH GERMAN (3) Intensive reading in Middle High German literature, especially of the *Blütezeit.* Prerequisite: Ger. 520.

522. OLD HIGH GERMAN (3) Essentials of the grammar with special treatment of the High German sound shift and of ablaut and umlaut; reading of works written before 1100 A.D.

523. GOTHIC (3) Introduction to historical and comparative Germanic grammar;

* No graduate credit is given for this course.

emphasis on the Gothic language and texts. Suitable for advanced students in English.

525. Old Icelandic (3) Introduction to Old Icelandic grammar; readings in Old Icelandic prose. Suitable for advanced students in English.

531. Seminar in Medieval German Languages and Literatures (3-6)

541. Seminar in the Literature of the Reformation and Baroque (3-6)

551. Seminar in the Literature of the Enlightenment and the Age of Goethe and Schiller (3-6)

561. Seminar in Post-Idealistic Literature (3-6)

571. Seminar in Modern German Literature (3-6)

581. Seminar in Literary Genres (3-12) Special studies in the German lyric, drama, short story, and novel.

591. Seminar in German Literary Criticism (3)

HIGHER EDUCATION (HI ED)

Robert E. Sweitzer
In Charge of Graduate Programs in Higher Education
205 Education and Psychology Center

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Sweitzer and Willower.
Graduate Faculty, Associate Members: Professor Godbey, Associate Professor Lindsay.

Graduate work in the general field of higher education is offered for persons interested in the study of higher education and for persons preparing for administrative positions in colleges and universities. Academic emphasis and research may be carried out in the following areas: academic administration; institutional research; student personnel administration; financial management; and continuing education. Preparation for administration in various institutions, including community and junior colleges, is provided through alternative patterns of courses, internships, topical seminars, independent study, and research. The resources of the University, of cooperating institutions, and of higher education agencies are utilized in preparing students to be able to integrate theory, practice, and research. Although each program option has a different emphasis and pattern, typically each student's program includes experiences dealing with the development and current nature of institutions of higher education, institutional administration, educational and/or philosophical foundations, research skills and computer programming, psychology and/or educational psychology, and social psychology or sociology.

The program is not available as a major to students who are preparing to give instruction in the arts, humanities, natural sciences, or social sciences. However, a minor program is available for those persons majoring in other departments and programs and who are interested in college and university teaching.

Although students with any undergraduate major may enter the program, degree requirements make certain prerequisites desirable. Requirements for admission to

the M.Ed. program include a broad undergraduate background in the liberal arts and sciences, including a minimum of a B average in 14 credits above the freshman level in the social and behavioral sciences, and a minimum junior-senior academic average of B minus (2.75). Completion of the M.Ed. program requires a B average in approximately 36 graduate credits, 18 of which must be in 500-series courses, and internship or apprenticeship experiences in a minimum of two different administrative units.

Requirements for admission to the D.Ed. program include a minimum 3.25 average in a master's degree program, a broad liberal arts and science background with a minimum average of B for 24 credits in the social and behavioral sciences on the undergraduate and graduate levels. A minimum of two years' experience in institutions of higher education or the equivalent is also required, as is a satisfactory rating on the Miller Analogies Test or the Graduate Record Examination.

In addition to the Graduate School and College of Education requirements for the D.Ed. degree, the student is expected to maintain a 3.30 minimum grade average, provide evidence of work or internship experience in at least three different administrative units or areas, and earn at least 30 credits in six or fewer consecutive terms in residence after completing the master's degree.

EDUCATIONAL SERVICES (ED SER)

545. Higher Education in the United States (2-3) Historical perspective and current status; development of functions and structures; issues in curriculum, admissions, government, administration, and finance.

546. The Principles of College Teaching (2-3) Principles involved in teaching at the college level; effective use of teaching aids; criteria used in evaluation.

547. Internship in Higher Education (1-9) Supervised experience in administrative offices, in research, on instructional teams, and in college teaching.

548. Curriculums in Higher Education (2-3) Various types of curriculums and philosophies underlying them; ways in which curriculums are developed; elective versus required courses; evaluation of achievement.

549. Community Junior College and the Technical Institute (2-3) Distinctive contributions to meeting the need for post-secondary education; development, functions, curriculum and instruction, government, administration and finance.

550. The Professional Education of Teachers (3) Development and present status of teacher education; objectives and standards; selection and guidance of students; personnel problems in relation to staff. Prerequisite: 6 credits in advanced courses in education and a course in educational psychology.

551. Student Personnel Programs in Higher Education (2-3) Student personnel services in higher education; organization of student advisory programs; use of personnel data; co-curricular activities; student welfare.

552. Administration in Higher Education (2-3) Philosophy of administration; principles of scientific management and their application in colleges and universities; case studies of administrative problems. Prerequisite: courses or experience in higher education.

553. Student Personnel Administration Theory and Research (2-3) Relations of theory, practice, and research on administrative behavior and student personnel services; case study, role playing, programmed decision problems. Prerequisites: Ed.Ser. 551, 555.

555. Seminar in Higher Education (1-6) Special topics in higher education.

HISTORY (HIST)

ROBERT K. MURRAY, *Head of the Department*
116 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Brown, Dahmus, Forster, Hassler, Klein, McNall, and Murray; Associate Professor Eggert.

Graduate Faculty, Associate Members: Professor Green; Associate Professors Ameringer, Frantz, Linker, Maddox, Meier, Pixton, and Sun; Assistant Professors Borza, Enteen, and Silverman.

Graduate work is offered in the following areas of history: ancient, medieval, Europe since 1500, Great Britain and the British Empire, Russia and Eastern Europe, the Far East, the United States, and Latin America. These areas are subdivided into chronological, national, and topical fields.

The candidate for the doctor's degree must pass examinations in one of the above areas, in a dissertation field within that same area, and in one field from a second area. He must also pass an examination in a single cognate field, or in a study area made up of a number of academic disciplines related to the subject of his dissertation. The candidate for the master's degree selects one of the above areas for examination and thesis purposes. He must take some work in an area other than his examination area, and he also must take work in a cognate field. A thesis is required of all M.A. candidates in this major.

The entering student should present evidence of undergraduate course work covering the history of Europe from ancient times to the present and the history of America from its discovery to the present. All applicants must provide Graduate Record Examination scores with their applications.

All students are advised that individual instructors may require a reading knowledge of pertinent languages for seminar work and for research on thesis topics.

HISTORY (HIST)

401.	CLASSICAL CIVILIZATION (3)	*Mr. Borza*
403.	THE MIDDLE AGES FROM CONSTANTINE TO THE CRUSADES (3)	*Mr. Dahmus*
404.	THE MIDDLE AGES FROM THE CRUSADES TO THE RENAISSANCE (3)	*Mr. Dahmus*
408.	INTELLECTUAL HISTORY OF THE MIDDLE AGES (3)	*Mr. Dahmus*
410.	THE RENAISSANCE (3)	*Mr. Spielvogel*
411.	THE REFORMATION (3)	*Mr. Spielvogel*
413.	THE AGE OF ABSOLUTISM (3)	*Mr. Green*
414.	THE FRENCH REVOLUTION AND THE NAPOLEONIC ERA (3)	
417.	NINETEENTH CENTURY EUROPE (3)	
419.	RECENT EUROPEAN HISTORY (3)	*Mr. Forster*
422.	HISTORY OF THE AMERICAN FRONTIER (3)	*Mr. McNall*
425.	HISTORY OF AMERICAN POLITICAL PARTIES (3)	*Mr. Stein*
426.	THE DIPLOMATIC HISTORY OF THE UNITED STATES TO 1900 (3)	*Mr. Maddox*
427.	THE DIPLOMATIC HISTORY OF THE UNITED STATES SINCE 1900 (3)	*Mr. Maddox*
428.	AMERICAN MILITARY HISTORY (3)	*Mr. Hassler*
430.	COLONIAL AMERICA TO 1753 (3)	
431.	REVOLUTIONARY AMERICA, 1753-1783 (3)	*Mr. Frantz*
432.	THE FORMATIVE PERIOD OF AMERICAN HISTORY (3)	*Mr. Brown*
433.	THE MIDDLE PERIOD OF AMERICAN HISTORY (3)	*Mr. Klein*
434.	THE UNITED STATES IN CIVIL WAR AND RECONSTRUCTION (3)	*Mr. Hassler*

435. The Emergence of Modern America (3) *Messrs. Murray and Stein*
436. Recent American History (3) *Mr. Murray*
439. History of England in the Middle Ages (3) *Mr. Dahmus*
440. Britain Under the Tudors and Stuarts, 1485-1688 (3) *Mr. Linker*
441. Great Britain, 1688-1832 (3) *Mr. Linker*
442. History of Russia to 1801 (3) *Mr. Thaden*
443. History of Russia, 1801-1917 (3) *Mr. Thaden*
444. Eastern Europe in Modern Times (3) *Mr. Thaden*
447. Social and Economic History of Europe Since 1750 (3) *Mr. Silverman*
448. Intellectual and Cultural History of Modern Europe (3) *Mr. Silverman*
449. Diplomatic History of Europe Since 1870 (3) *Mr. Forster*
452. Social and Cultural History of the United States Since 1783 (3) *Mr. Brown*
453. American Economic History in the Agricultural Era (3) *Mr. McNall*
454. American Economic History in the Industrial Era (3) *Mr. Eggert*
456. (L.M.R. 456) History of American Labor (3) *Mr. Eggert*
458. Constitutional History of the United States to 1877 (3) *Mr. Stebbins*
459. Constitutional History of the United States Since 1877 (3) *Mr. Stebbins*
460. Latin America and the United States (3) *Mr. Ameringer*
461. Social and Cultural History of Latin America (3) *Mr. Garner*
462. Mexico and the Caribbean Nations in the 20th Century (3)
467. Alexander the Great and the Hellenistic World (3) *Mr. Borza*
468. The Roman Republic (3) *Mr. Borza*
469. The Pax Romana (3) *Mr. Borza*
471. Nineteenth Century China (3) *Mrs. Sun*
472. Twentieth Century China (3) *Mr. Duiker*
479. Modern Vietnam, Laos, and Cambodia (3)
480. The Medieval Middle East, 600-1800 (3) *Mr. Goldschmidt*
481. The Middle East in Modern Times (3) *Mr. Goldschmidt*
491. History of the Soviet Union (3) *Mr. Enteen*
492. Great Britain Since 1832 (3) *Mr. Linker*
497. Germany Since 1640 (3) *Mr. Silverman*
498. Selected Topics in History (3-6)

501. Historical Method (3) *Mr. Meier*

502. Historiography (3) *Mr. Meier*

503. Studies in Medieval English History (3-6) A seminar in the political, economic, and cultural history of England in the Middle Ages. *Mr. Dahmus*

504. Medieval Civilization (3-9) *Mr. Dahmus*

505. The Age of the Reformation (3-6)

507. Studies in European History, 1600-1750 (3-6)

508. Studies in European History, 1750-1900 (3-6) *Mr. Silverman*

509. Studies in Twentieth Century Europe (3-6) *Mr. Forster*

512. Studies in Pennsylvania History (3-6) *Mr. Klein*

520. Colonial and Revolutionary America (3-6) *Mr. Frantz*

533. The United States, 1783-1860 (3-6) *Mr. Klein*

534. The United States, 1860-1877 (3-6) *Mr. Hassler*

535. The United States, 1877-1919 (3-6)

536. The United States Since 1919 (3-6) *Mr. Murray*

538. Diplomatic History of the United States (3-6) *Mr. Maddox*

539. Economic History of the United States (3-6) *Messrs. McNall and Eggert*

540. Studies in British History (3-6) *Mr. Linker*

544. Seminar in Eastern European History (3-6)

545. Studies in Russian and Soviet History (3-6) *Mr. Enteen*

550. Problems in History (3-6)

552. Cultural History of the United States (3-6) *Mr. Brown*

562. Seminar in Latin-American History (3-6) *Mr. Ameringer*

563. Studies in the History of the Caribbean Area (3) Prerequisites: Hist. 22, 23. *Mr. Ameringer*

568. Studies in Greek History (3-6) *Mr. Borza*

569. Studies in Roman History (3-6) *Mr. Borza*

598. Readings in History (1-6)

HOME ART (H ART)

William J. McHale
In Charge of Graduate Programs in Home Art
S-38B Human Development Building

A candidate for an advanced degree may choose a minor in home art upon approval by his major department. However, no advanced degree is offered in this field.

HOUSING AND INTERIORS (H I)

401. Advanced Interiors I (3)
402. Advanced Interiors II (3-9)
410. Textile Design I (3)
411. Textile Design II (3)
412. Textile Design III (3)
470. Housing Problems and Policies (3)

FAMILY HOUSING AND HOME ART (FH HAR)

515. Backgrounds of the Home Arts (3) Evaluation of useful objects in respect to their form, function, and time; selections for exhibition.

530. Problems in Family Housing and Home Art (1-6) Individual investigation, analysis, and presentation.

541. Art in the Environment (3) Approach based upon human needs with consideration of materials in the light of their use in home living.

HOME ECONOMICS EDUCATION (HE ED)

MARJORIE EAST, *Head of the Department*
212 Education and Psychology Center

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors East and Hatcher.
Graduate Faculty, Associate Member: Associate Professor Ray.

Research and graduate courses may be chosen to give emphasis to special areas of interest in home economics education, such as curriculum development; evaluation; teaching at the elementary, secondary, adult, or higher education levels; supervision; administration in colleges; or research.

For admission the student must present approximately 50 credits of undergraduate work from the following areas: home economics education, education and/or psychology, aspects of home economics; the physical and biological sciences; and the social sciences.

HOME ECONOMICS EDUCATION (HE ED)

400, 400v. SPECIAL PROBLEMS IN HOME ECONOMICS EDUCATION (1-3)
406, 406v. AUDIO-VISUAL METHODS FOR HOME ECONOMICS (1-4)
410v. SUPERVISION OF STUDENT TEACHERS (1-3)
427, 427v. TEACHING HOME ECONOMICS (3)
443, 443v. ADULT EDUCATION IN HOME ECONOMICS (3)
463, 463v. SENIOR SEMINAR (2)
466, 466v. STUDENT TEACHING (9)
477, 477v. CURRICULUM DEVELOPMENT FOR HOME ECONOMICS IN SECONDARY SCHOOLS (3)
478, 478v. APPRAISING STUDENT PROGRESS IN HOME ECONOMICS (3)
479, 479v. READINGS IN HOME ECONOMICS EDUCATION (1-4)
480, 480v. PROBLEMS IN TEACHING HOME ECONOMICS (3-6)
481v. EMPLOYMENT PREPARATION PROGRAMS IN VOCATIONAL HOME ECONOMICS (3)

502, 502v. HOME ECONOMICS INSTRUCTION AT THE COLLEGE LEVEL (3) Teaching techniques suitable for college instruction in home economics; for prospective home economics college teachers.

503, 503v. HOME ECONOMICS TEACHER EDUCATION (3) Organization of college programs of teacher education; use of resources; records; field services; recruitment and selection of personnel. Prerequisite: two years' experience in teaching home economics.

504, 504v. EDUCATIONAL ISSUES AND HOME ECONOMICS (3) Contemporary issues in education and their relationship to the teaching of home economics. Prerequisite: teaching experience.

510, 510v. EDUCATIONAL LEADERSHIP IN HOME ECONOMICS (2-6) Principles of educational leadership for home economists preparing for administration; supervision of city and state programs; supervision of student teachers. Prerequisites: graduation from a four-year teacher education major and two years' teaching experience in home economics.

511, 511v. INTERNSHIP IN HOME ECONOMICS SUPERVISION AND ADMINISTRATION (2-8) Opportunity to understudy an educational leader in student teacher super-

vision, state supervision, department or college administration, or regional consultation. Prerequisite: H.E.Ed. 510.

518, 518v. Evaluation of Home Economics Programs (3) Methods of evaluating progress toward goals in home economics education and use of findings in program planning and revision.

521, 521v. Home Economics Education Seminar (2-3) Selected topics and recent developments in home economics education. Conferences and guidance relative to individual research problems.

530, 530v. Problems in Home Economics Education (1-6 per term) Individual investigation of problems related to the teaching, supervision, or administration of home economics education.

HORTICULTURE (HORT)

Darrell E. Walker, *Head of the Department*
101 Tyson Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Hitz, Larson, Meahl, Odland, Ritter, Smith, Tukey, and Walker; Associate Professors Bergman, Creech, McArdle, and Stinson.

Graduate Faculty, Associate Members: Professor Mastalerz; Associate Professors Haramaki and Pfahl; Assistant Professors Craig and White.

Students may specialize in propagation, several phases of production, fruit and vegetable processing, plant genetics and breeding, plant nutrition, and various environmental and post-harvest physiological studies of horticultural crop species.

Students wishing additional credits in floriculture, olericulture, ornamental horticulture, plant breeding and genetics, plant nutrition, or pomology should register for Hort. 501.

Prerequisites for admission vary according to the area of specialization; but basic courses in physical sciences, mathematics, and biological sciences are required. Students who lack prerequisite courses may be admitted but are required to fulfill deficiencies without degree credit.

HORTICULTURE (HORT)

401.	Plant Propagation (3)	*Mr. Haramaki*
402.	Plant Nutrition (3)	*Mr. Bergman*
403.	Horticultural Plants and Their Environment (3)	*Mr. Mastalerz*
404.	Advanced Horticultural Crop Science (3-12)	*Mr. Walker*
405.	Senior Seminar in Horticulture (1-2)	
407.	Plant Breeding (3)	*Mr. Creech*
412.	Post-Harvest Physiology (3)	*Mr. Ritter*
444.	Advanced Plant Breeding (3-6)	*Mr. Craig*
447.	Problems in Horticulture (1-9)	
451.	Flower Store Management (4)	*Mr. Pfahl*

500. Ecology of Fruit Plants (3) Factors limiting the distribution and intensity of culture of fruit species and varieties and effect of environmental factors on cultural practices. Spring term, even years. *Mr. Tukey*

501. Experimental Problems in Horticultural Science (1-12) Investigation of problems in floriculture, olericulture, ornamental horticulture, plant breeding, nutrition, or pomology. *Mr. Walker*

506. Nutrition of Horticultural Crops (2-4) Principles, applications, and interpretations of diagnostic methods for determining fertilizer requirements of horticultural crops. *Mr. Smith*

512. Principles of Fruit and Vegetable Storage (2-4) Principles involved in the maturation, storage, and senescence of fruits and vegetables, and their application. Winter term, odd years. *Mr. Ritter*

514. Propagation and Improvement of Horticulture Plants (1-6) Biological factors affecting sexual and asexual propagation of plants; techniques in plant improvement; maintenance of propagation material. *Mr. Meahl*

517. Horticultural Seminar (1 per term) Review of current research publications in horticulture. Each student presents one or more reviews of assigned topics.

520. Genetics and Breeding Seminar (1 per term) Review of research and literature in genetics and breeding of horticultural crops.

524. Experimental Procedures in Horticultural Research (3) *Mr. Craig*

525. Horticultural Research Techniques (3) Practice in and comparison of methods and apparatus used in horticultural research. Winter term, even years. *Mr. Tukey*

528. Problems in Fruit and Vegetable Processing (2-12) *Mr. McArdle*

INDUSTRIAL ARTS EDUCATION (I ART)

John Withall, *Head of the Department of Secondary Education*
164 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Member: Associate Professor Pendered.
Graduate Faculty, Associate Member: Associate Professor Shemick.

Emphasis may be placed on research, curriculum development, or teacher education. Graduation from an approved major in industrial arts and at least 18 credits in education and related psychology are required for admission.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

INDUSTRIAL ARTS (I ART)

400. Shop Management and Layout (3)
407. Curriculum Materials and Methods in Industrial Arts (4)
470. Problems in Senior High School Industrial Arts (3)

574. History and Philosophy of Industrial Arts (2-3) Historical developments and concurrent educational philosophies of industrial arts in American education. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

575. Problems in Industrial Arts Education (2-3) Subject matter, projects, methods of manual and informational teaching, aids and devices, selection of text and reference materials, personnel organization, shop management, problem pupils. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

576. Supervision and Administration of Industrial Arts Education (2-3) How to organize, supervise, and administer functioning programs of industrial arts; duties of a supervisor and director of industrial arts. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

577. Testing in Industrial Arts (2-3) Construction of informal manipulative and written tests; use of standardized mechanical aptitude and achievement tests; construction and use of rating scales; scoring and grading; interpretation of test results. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

578. Research in Industrial Arts (2-3) Research techniques in industrial arts education. Prerequisite: 6 credits in professional courses in industrial arts.

580. Seminar in Industrial Arts (2-9) Directed intensive study, investigation, or research in selected phases of the program; reports and constructive criticism. Prerequisites: 6 credits in professional courses in industrial arts and teaching experience.

INDUSTRIAL ENGINEERING (I E)

Benjamin W. Niebel, *Head of the Department*
207 Hammond Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Lancaster, Niebel, and Schmidt; Associate Professor Ham.

Graduate Faculty, Associate Members: Professors Thuering and Zindler; Associate Professors Addison, Draper, Freark, and Raphael; Assistant Professors Ermer and Guild.

Graduate study and research are conducted in management science, production engineering, process design, systems engineering, and human engineering.

Qualified graduates in industrial engineering, other engineering curriculums, and mathematics will be considered for admission.

INDUSTRIAL ENGINEERING (I E)

400. Engineering for Production (3)
402. Engineering Economy (3)
403. Engineering Economy and Statistics (3)
404. Management Science (3)
405. Quantitative Methods in Industrial Engineering III (3)
406. Design of Production and Distribution Systems (3)
422a,b,c,d,e,f. Industrial Engineering Problems (2-12)
423. Quality Control (3)
424. Job Evaluation (3)

425. Introduction to Operations Research (3)
426. Industrial Automation (3)
427. Solidification of Castings (3)
428. Foundry Engineering (3)
430. Industrial Leadership (3)
432. Industrial Engineering Lectures (1-3)
438. Metal Cutting Principles and Practice (3)

501. Manufacturing Methods (2-8) Special projects including investigation; experimentation, design, and research of one or more special types of manufacture.

502. Management Methods (3-6) Scientific management, including management controls and mathematical programming; research on special problems.

503. Industrial Relations (1-6) Study of human problems related to labor unions, hierarchy, specialization; analysis of organizational structure, policies, decision criteria, and communication systems.

504. Advanced Quantitative Methods in Industrial Engineering (3) Study of statistical and analytical decision models important in industrial engineering with emphasis on inference and testing of hypotheses. Prerequisites: Math. 62 and 3 credits in statistics.

506. Advanced Work Design and Measurement (3-9) Methods of research in motion and time study; critical analysis of current literature.

507. Budgetary Control and Standard Costs (3-6) Divisional budgets as control media; establishing standard cost data, standard cost accounting procedures, and the use of cost variances in controlling manufacturing operations. Prerequisite: I.E. 335.

508. Methods of Operations Research (3) Analytical approach to management decision-making including decision theory, game theory, constrained extremum theory; minimum cost transportation and network models. Prerequisites: Math. 100 and 3 credits in statistics.

509. Methods of Operations Research (3) Theory and application in decision-making including sequencing, line balancing, inventory, replacement, waiting line models, and Monte Carlo simulation. Prerequisites: Math. 100 and 3 credits in statistics.

510. Methods of Operations Research (3) Theory and application of mathematical programming including linear and dynamic programming, and an introduction to nonlinear, integer, and stochastic programming. Prerequisite: Math. 100.

511. Experimental Design in Engineering (3) Statistical design and analysis of experiments in engineering; experimental models and experimental designs using the analysis of variance. Prerequisites: Math. 63 and 3 credits in statistics.

513. Real Time Data Processing for Engineering Systems (3) Random access computers and communication components for real time systems; engineering systems simulation on digital computers. Prerequisite: Cmp.Sc. 102 or 410.

528. Metal Cutting Theory (3) Study of the theory of metal cutting, contemporary and future problems of metal removal processes; critical analysis of current literature. Prerequisite: I.E. 438.

538. Experimental Investigations in Materials Processing (3) Experimental investigation on selected subjects in processing involving instrumentation, methods, and analysis. Prerequisite: I.E. 528.

JOURNALISM (JOURN)

HENRY F. SCHULTE, *In Charge of Graduate Programs in Journalism*
215 Carnegie Building

Degree Conferred: M.A.

Graduate Faculty, Senior Member: Professor Brown.

Graduate Faculty, Associate Members: Professors Goodwin and Harrison; Associate Professors Froke, Norris, Pockrass, and Schulte; Assistant Professor Jones.

The program is designed to give students an understanding of the theory and practice of mass communication, a critical insight into the structure and functions of mass communications industries, an introduction to research on communications problems, and an opportunity to acquire some depth in a minor field of study. Fulfilling the requirements for this degree should qualify students to advance in positions of responsibility and leadership in the professions of journalism, advertising, broadcasting, and public relations; or in communications education and research.

The program is designed primarily for students who have had some professional courses or experience in journalism and mass communications. Other students will be required to complete a series of at least three undergraduate courses.

A thesis and a minor of 12 credits are required of all M.A. candidates in this major.

JOURNALISM (JOURN)

401. CRITICS AND ETHICS OF THE MASS MEDIA (3) *Mr. Harrison*
405. INTERNATIONAL MASS COMMUNICATIONS (3) *Mr. Schulte*
406. EVALUATION AND USES OF MASS COMMUNICATIONS RESEARCH (3)
419. (Spch. 419) COMPARATIVE BROADCASTING SYSTEMS (3)
421. EDITORIAL INTERPRETATION (3) *Messrs. Harrison and Brown*
422. CULTURAL ASPECTS OF THE MASS MEDIA (3) *Mr. Pockrass*
424. PUBLIC AFFAIRS REPORTING (3) *Mr. Dulaney*
430. JOURNALISM IN THE SCHOOLS (3-6)
436. (Soc. 436) SOCIOLOGY OF OPINION FORMATION (3)
442. SPECIAL TOPICS IN ADVERTISING (3)
443. ADVERTISING CAMPAIGNS (3) *Mr. Rotzoll*
444. ADVERTISING IN CONTEMPORARY SOCIETY (3) *Mr. Norris*
466. PUBLIC RELATIONS PROBLEMS (3)
468. LAW OF MASS COMMUNICATIONS (3) *Mr. Smith*
481. NEWS EVALUATION AND PRESENTATION (3) *Mr. Harrison*
492. PUBLIC AFFAIRS BROADCASTING (3) *Mr. Farson*
499. INDEPENDENT STUDY IN MASS COMMUNICATION (2-6) *Mr. Goodwin*

504. SEMINAR IN THE HISTORY OF MASS COMMUNICATION (3) *Mr. Schulte*

505. INTERNATIONAL COMMUNICATION PROBLEMS (3) Legal and communications problems of the international flow of news and opinion; international press codes.

506. INTRODUCTION TO MASS COMMUNICATIONS RESEARCH (3) The scientific method; survey of basic concepts of theoretical and empirical research; variety of methodology; criteria for adequate research.

508. THE LITERATURE OF JOURNALISM (3) *Mr. Brown*

510. MASS COMMUNICATIONS RESEARCH METHODS I (3) Design of research on processes and effects of mass communications; data analysis and hypothesis testing. Prerequisite: Journ. 506 or Stat. 400.

511. Mass Communications Research Methods II (3) Problems of bibliographical research; evaluation of sources and materials in mass communications history, biography, structure, ethics, and other areas. Prerequisite: Journ. 506.

513. Constitutional Problems of the News Media (3) Problems involving conflict between guarantees of press freedom in the First and Fourteenth Amendments and rights and privileges of others. *Mr. Harrison*

521. News Media and Public Opinion (3) Problems in the function, techniques, and responsibilities of press, radio, and television in forming and interpreting opinion. Prerequisite: Pl.Sc. 427. *Mr. Pockrass*

524. Government and Mass Communications (3) Problems of freedom of information; governmental efforts to control mass communication agencies; government news coverage; public information agencies. *Mr. Goodwin*

540. Seminar in Advertising Problems (3) *Mr. Norris*

545. Advertising and Consumer Behavior (3) Examination of theories of human behavior as they apply to the study of advertising's effects on consumer behavior.

585. Comparative Theories of Press Systems (3) Institutional structure and normative functions of press systems in modern societies, as shaped by prevailing world view and social organization. *Mr. Norris*

LABORATORY ANIMAL MEDICINE (L A M)

C. Max Lang, *Director, Animal Resource Facility*
The Milton S. Hershey Medical Center

Degree Conferred: M.S.

Graduate Faculty, Associate Member: Assistant Professor Lang.

This is a postdoctoral program to train graduate veterinarians for careers in research and comparative medicine. Graduates of the program will be qualified to direct research animal facilities, aid biomedical investigators in the proper care and selection of research animals, advise investigators on spontaneous diseases which can complicate comparisons between animals and man, and conduct independent research. All students in the program will receive breadth of scholarship in comparative medicine by taking a minor in one of the basic medical sciences. All teaching and research for this program will be conducted at the College of Medicine.

This program is offered only at the Milton S. Hershey Medical Center. For course listings at the Center see pages 245 to 248.

MATHEMATICS (MATH)

Raymond G. D. Ayoub, *Head of the Department*
228 McAllister Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Anderson, Axt, C. Ayoub, R. Ayoub, Chowla, Fine, A. Frink, O. Frink, Hammer, Hunter, Kanwal, H. Krall, Mitchell, Mrowka, Patil, Ribeiro, Schoenfeld, and Sheffer; Associate Professors Andrews, Harkness, A. Krall, and Petrich.

Graduate Faculty, Associate Members: Professor Bartoo; Associate Professors Mack, M. McCammon, and Rung; Assistant Professors Bollinger, Bond, Deutsch, Hahn, Hughes, James, Jolly, McLaughlin, Morris, Pearson, Shapiro, and Stevens.

Graduate courses in all the principal branches of mathematics are offered each year. The department is prepared to direct research in a variety of fields, including various branches of analysis, algebra, topology, number theory, numerical analysis, applied analysis, and mathematical logic and foundations. A digital computer is available on the campus for students interested in numerical methods.

To be admitted to the M.A. or Ph.D. program without undergraduate deficiency, an applicant should have completed at least three courses in mathematics at the advanced undergraduate level (400 series) or their equivalents. The undergraduate student is urged to take at least 6 credits in foundations of analysis (Math. 420-421) *and* 6 in modern algebra (Math. 480-481) or their equivalents. These courses are essential to prepare for the graduate program and, if they are taken after admission, only 6 credits at most may be counted toward an advanced degree.

For the M.A. degree the department offers two options:

(1) The *thesis* option requires 12 credits of approved 500-series courses in mathematics, 6-9 credits of thesis, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a final (oral) examination based on the thesis and general course material.

(2) The *non-thesis* option requires 18 credits of 500-series courses in mathematics with grades of A or B, sufficient credits in approved 400- or 500-series courses to make a total of 30 credits, and a term paper on an approved topic of mathematics. No final examination is given in this option.

All first-year students who are working toward the M.A. or Ph.D. degree are required to enroll in Math. 498 for two successive terms. All Ph.D. students, before they have accumulated 48 graduate credits earned at this university or elsewhere, *must* take qualifying examinations in three fields of mathematics and a reading examination in French, German, or Russian. Recommendations for advancement to Ph.D. candidacy are based on these examinations. The comprehensive examination is given after approximately 60 credits and only after the student has passed a reading examination in a second of the foregoing languages.

To be admitted to the M.Ed. program without undergraduate deficiency in mathematics, an applicant should have at least 24 credits in mathematics including at least 6 at the intermediate level beyond calculus.

For the D.Ed. degree, a student must pass a reading examination in French, German, or Russian before he is allowed to take the comprehensive examination. In addition to the major thesis, the department requires a minor thesis on an assigned topic in mathematics.

Special courses have been instituted for the training of teachers. Among these are Math. 400, 401-402, 415, 416, and 470-471. These are acceptable for the satisfaction of credit requirements only for the M.Ed. and D.Ed. degrees.

MATHEMATICS (MATH)

400. Probability for Teachers (3)
401-402. Geometry for Teachers (3 each)
404. Theory of Numbers (3)
405. (A.M. 405) Fourier Series and Partial Differential Equations (3)
406. Topics in Theory of Numbers (3)
407. Foundations of Algebra and Geometry (3)

409-410. (Stat. 409-410) Introduction to Mathematical Statistics (3 each)
411. Finite Differences (3)
413-414. Mathematics of Science for Teachers (3 each)
415. Survey of Modern Mathematics for Teachers (3)
416. Mathematical Logic for Teachers (3)
417. (A.M. 417) Tensor Analysis (3)
418. (A.M. 418, Stat. 418) Discrete Probability Theory (3)
420-421. Introduction to Analysis (3 each)
428. (Phil. 428) Logical Theory (3)
431. (A.M. 431) Ordinary Differential Equations (3)
435. Axiomatic Set Theory (3)
441. (A.M. 441) Matrix Algebra (3)
452. (A.M. 452) Functions of a Complex Variable (3)
453. (Cmp.Sc. 453) Numerical Computations (3)
454. (Cmp.Sc. 454) Matrix Computations (3)
470-471. Algebra for Teachers (3 each)
472. Foundations of Geometry (3)
473. Elementary Point-Set Topology (3)
480-481. Introduction to Modern Algebra (3 each)
491. Topics in Applied Mathematics (3-9)
498. Mathematics Seminar (1-6)

501-502. Theory of Functions of a Real Variable (3 each) Sets, metric spaces, measure and integration, Lp spaces and other function spaces, differentiation. Prerequisite: Math. 421.

503. Fourier Analysis (3) Fourier series and integrals, convergence and summability, theorems on Fourier coefficients, uniqueness properties. Prerequisite or concurrent: Math. 502.

505. Integral Equations (3) Fredholm and Volterra equations, and applications. Prerequisite: Math. 421.

507. Calculus of Variations (3) Prerequisite: Math. 421.

508-509. Complex Analysis (3 each) Analytic and meromorphic functions; Riemann's mapping theorem. Prerequisite: Math. 421.

511. Linear Algebra (3) Vector spaces and linear transformations, canonical representations, elementary divisors and invariant factors. Prerequisite: Math. 481 or 537.

515. Partial Differential Equations of Mathematical Physics (3) Methods of solution of selected elliptic, parabolic, and hyperbolic partial differential equations, with reference to physical application. Prerequisite: Math. 421.

517-518. (Stat. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

523. Metric Differential Geometry (3) The usual classical treatment of the subject. Prerequisite: Math. 63.

524. Advanced Complex Analysis (3) Topics include boundary behavior of analytic functions, bounded analytic functions, conformal mapping, theory of Riemann surfaces. Prerequisite: Math. 509.

525. Theory of Functions of Several Complex Variables (3-6) Topics include fundamental properties of holomorphic functions, complex analytic manifolds, integral representations, Cousin problems. Prerequisite: Math. 509.

529-530-531. Topology (2 each) Topological, product, compact, metric, and connected spaces; continuous functions, separation axioms, countability conditions, combinatory topology.

532. Theory of Sets (3) Formal development of set theory on a logical basis and related methodological problems; applications to the foundations of mathematics. Prerequisite: Math. 428.

533. Analytic Theory of Numbers (2-6) Topics selected from Dirichlet's Theorem on primes in A. P., Riemann Zeta-function, distribution of primes, Waring's problem, Goldbach's problem, partitions. Prerequisites: Math. 404 or 480; Math. 508.

534. Elementary and Algebraic Number Theory (2-6) The arithmetic and ideal theory of higher algebraic number fields will be emphasized, together with the necessary rational number theory. Prerequisite: Math. 480.

535-536-537. Algebra (2 each) Basic theory of semigroups and groups, rings and modules, fields, lattices, and linear algebra. Prerequisite: Math. 481.

538-539-540. Rings and Homological Algebra (2 each) Selected topics including structure theory of rings and an introduction to categories and functions. Prerequisite: Math. 537.

542-543. (Stat. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

544-545-546. General Topology (2 each) Topics selected including uniform spaces, function spaces, and proximity spaces. Prerequisite: Math. 531.

547-548-549. Lie Theory (2 each) Topics selected from theory of topological semigroups, topological groups, lie groups, transformation groups. Prerequisite: Math. 531.

550-551. (Phil. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or 428.

552. Numerical Analysis (3) Interpolation; remainder theory; approximation of functions; error analysis; orthogonal polynomials; approximation of linear functionals; functional analysis applied to numerical analysis. Prerequisites: Math. 420, 453.

553. Numerical Analysis (3) Eigenvalue and eigenvector determination; numerical solution of integral equations and ordinary differential equations with error and stability analysis. Prerequisites: Math. 420; Math. 454 or 481.

554. (Phil. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Math. 428.

556. (Phil. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions, recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Math. 428.

557. (Phil. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisites: Math. 554, 556.

558-559. (Stat. 558-559) Theory of Stochastic Processes (3 each) Stationary,

independent, and orthogonal processes; discrete and continuous Markov processes; martingales and semi-martingales applications. Prerequisite: Math. 518.

560-561. Theory of Differential Equations (3 each) Topics selected from existence and uniqueness of solutions of differential systems, Sturm-Liouville systems, eigenvalue problems, integral operator solutions. Prerequisites: Math. 72 or 83 or 100, and 508.

562. Theory of Special Functions (3) Topics include asymptotic expansions; Riemann-Papperitz and Trusdell's F equations; orthogonal polynomials; generating, beta, zeta, hypergeometric, Bessel, Legendre, elliptic functions. Prerequisites: Math. 72 or 83 or 100 and either Math. 420 and Math. 452 or Math. 508.

563. Approximation Theory (3) Approximation in normed spaces; existence, uniqueness, characterization, computation of best approximations; error bounds; degree of approximation; approximation of linear functionals. Prerequisites: Math. 501, 453.

564. Numerical Solution of Partial Differential Equations (3) Numerical solution of initial and boundary-value problems; eigenvalues and eigenfunctions; errors, stability, and convergence. Prerequisite: Math. 552.

565. Functional Analysis (3) Theory of Banach and Hilbert spaces, including functionals and operators, and related topics. Prerequisite: Math. 502.

570. Special Topics in Geometry (3-12)

571. Special Topics in Analysis (3-12)

572. Special Topics in Algebra (3-12)

573. Special Topics in Applied Mathematics (3-12)

574. Special Topics in Foundations of Mathematics (3-12)

575-576. Mathematics Seminar (1-6 each) Selected topics from recent mathematical developments.

577. (Stat. 577) Special Topics in Probability (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

578. Special Topics in Topology (3-12)

579. Special Topics in Numerical Analysis (2-12)

*580. Special Topics in Number Theory (2-12)

581-582-583. Group Theory (2 each) Selected topics from group theory including Abelian, solvable, nilpotent, and free groups, Sylow theorems, and group extensions and representations. Prerequisite: Math. 537.

584-585-586. Algebraic Topology (2 each) Development of singular and Cech homology and cohomology theories; homotopy and cohomotopy theories. Prerequisite: Math. 531.

587-588-589. Point Set Topology (2 each) Topics selected from point set topology including upper semicontinuous and continuous decompositions, theory of continua, dimension theory. Prerequisite: Math. 531.

591. (Stat. 591) Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

* Credits to be arranged, 2-3 per term.

MECHANICAL ENGINEERING (M E)

RICHARD G. CUNNINGHAM, *Head of the Department*
207 Mechanical Engineering Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Ambrosius, Brickman, Cunningham, DiIlio, McLaughlin, Meyer, Olson, Queer, Reethof, and Shearer; Associate Professors Brighton, Heinsohn, Lestz, and Schmidt.

Graduate Faculty, Associate Members: Associate Professors DeCarolis, Faeth, Park, Parke, Wolgemuth, and Zimmerman; Assistant Professors Baker, Bowlus, and Wampold.

Graduate programs and research facilities are available in thermodynamics and combustion, heat transfer, fluid mechanics, dynamic system analysis, mechanical design, automatic controls, and fluid amplifiers. Air pollution control, automotive safety, designing for noise control and for reliability also provide many research and design opportunities.

The entering student must hold a bachelor's degree in engineering or physical science.

MECHANICAL ENGINEERING (M E)

401. MECHANICAL ENGINEERING (3-12)
402. AIR CONDITIONING AND LIFE SUPPORT SYSTEMS (3)
403. ROCKET PROPULSION (3)
405. SMALL PARTICLE TECHNOLOGY (3)
409. GAS TURBINES (3)
410. POWER PLANTS (3)
411. REFRIGERATION (3)
412. HEAT TRANSFER (3)
413. INTERNAL COMBUSTION ENGINES (3)
417. THEORY OF ENGINEERING INSTRUMENTS (3)
418. PRINCIPLES OF TURBOMACHINERY (3)
421. (Aersp. 421) INTERMEDIATE VISCOUS FLOW (3)
422. (Aersp. 422) INTERMEDIATE INVISCID FLOW (3)
450. DESIGN OF MACHINE TOOLS (3)
451. ADVANCED MACHINE DESIGN PROBLEMS (3)
452. DESIGN ANALYSIS (3)
453. BEARING DESIGN AND LUBRICATION (3)
455. AUTOMATIC CONTROL SYSTEMS (3)
457. ADVANCED MECHANISMS (3)

500. SPECIAL TOPICS IN THERMODYNAMICS (2-6)

503. THERMODYNAMIC PROCESS ANALYSIS (3) Development of equations governing separate processes in complete machines to give basic system parameters and characteristics; transient processes; irreversible effects.

504. ADVANCED ENGINEERING THERMODYNAMICS (3-6) Pure and applied thermodynamics including its application to advanced engineering problems; collateral reading and discussion of the classical works on the subject. Prerequisite: M.E. 42.

506. SELECTED TOPICS IN MECHANICAL ENGINEERING (1-12) Advanced courses adapted to the individual requirements of graduates in mechanical engineering.

512. Heat Transfer—Conduction (3) One- and two-dimensional conduction heat transfer for steady state and transient systems with varying boundary conditions.

513. Heat Transfer—Convection (3) Laminar and turbulent flow heat transfer in natural and forced convection systems.

514. Heat Transfer—Radiation (3) Thermal radiation fundamentals; specular and diffuse systems; differential and integral methods; numerical techniques; industrial applications.

517. Special Topics in Transport Phenomena (2-6)

519. Compressible Fluid Flow (2-4) Two-dimensional subsonic flow; similarity rules; theory of characteristics; supersonic and hypersonic flows; nonsteady flow; oblique shock waves.

521. Electromagnetic and Thermodynamic Flow Systems (3) Thermodynamic equations for flow of reacting and nonreacting fluids in electromagnetic fields; applications to engineering problems.

522. Boundary Layer and Separated Flows (3) Behavior of viscous fluids, with emphasis on boundary layer and separation effects in internal flow.

540. Simulation of Mechanical Engineering Phenomena (3) Analog and numerical methods for simulation of problems in thermodynamics, heat transfer, fluid mechanics, diffusion, and machine dynamics.

550. Analysis of Design Problems (3) Case problems in machine design requiring integrated application of engineering knowledge.

551. Special Topics in Design and Controls (2-6)

552. Advanced Dynamics of Machines (3-6) Linear and torsional vibrations in and balancing of rotating and reciprocating machinery; exact analysis of stresses produced by these and other dynamic forces in machine parts. Prerequisites: E.Mch. 12, M.E. 54.

553. Friction and Lubrication (3) Sliding and rolling surface phenomena; hydrostatic, hydrodynamic, and magnetohydrodynamic lubrication theory; design and control of gas and fluid lubricated bearings.

555. Automatic Control Systems (3) Advanced problems and techniques in the design of automatic control systems with emphasis on stability, controller design, and optimum performance. Prerequisite: M.E. 455.

556. Advances in Control Systems Analyses (3) Control system theory and applications of newly developed theory to engineering systems; nonlinear systems, distributed systems, state-space methods.

557. Mechanism Synthesis (3) Geometrical and algebraic methods for synthesizing planar and spatial mechanisms, dynamics of spatial mechanism.

558. Fluid Control Systems (3) Systems elements, simplified models, analysis of interacting elements, instrumentation; computer-aided case study, and experimental investigations.

580. Investigation Projects (2-6) Special experimental studies or investigations in mechanical engineering, adapted to individual requirements.

METALLURGY (METAL)

ROBERT W. LINDSAY
In Charge of Graduate Programs in Metallurgy
221 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Lindsay, Muan, and Read; Associate Professors Healy, Hoke, Inman, and Ryba.

Graduate Faculty, Associate Members: Associate Professors Bitler and Simkovich.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree.

A student may specialize, through both course work and research, in the science and engineering aspects of chemical, physical, or mechanical metallurgy.

A bachelor's degree is required in metallurgy, metallurgical engineering, or any other field which has included mathematics through ordinary differential equations, basic physics, and chemistry—covering chemical principles and, preferably, physical chemistry. Opportunity is provided to make up possible undergraduate deficiencies.

METALLURGY (METAL)

401. METALLURGICAL PROCESSES AND KINETICS (3)
402. ELECTROMETALLURGY, HYDROMETALLURGY, AND CORROSION (3)
404. PYROMETALLURGY (3)
405-406. METALLOGRAPHY (3 each)
407. METALLURGICAL ENGINEERING I (3)
408. METALLURGICAL ENGINEERING II (3)
410. METALLURGICAL INVESTIGATIONS II (2)
412. SOLID-STATE METALLURGY (3)
459. METALLURGICAL APPLICATIONS FOR ENGINEERS (3)

501. METALLURGICAL PROBLEMS (1-6 per term) Independent study of special problems in metallurgy.

502. SEMINAR IN METALLURGY (1-6) Conferences, reading, reports, and special lectures.

508. KINETICS OF PHASE TRANSFORMATIONS (3) Application of statistical mechanics and absolute rate theory to kinetics of phase transformations, including diffusion, nucleation, and growth rates. *Mr. Bitler*

509. INTRODUCTORY THEORETICAL PHYSICAL METALLURGY (3) Quantum mechanics and its application to solid-state theory; introduction of Schroedinger's equation, its solutions, free-electron model, band model. *Mr. Bitler*

510. MAGNETIC AND TRANSPORT PROPERTIES OF MATERIALS (3) Treatment of the magnetic and transport properties of solids by quantum mechanics with applications to practical alloy development. Prerequisite: Metal. 509. *Mr. Bitler*

511. ADVANCED PHYSICAL METALLURGY (3) Physical metallurgy of an advanced nature; consideration of solid state bonding, crystal structure, alloy constitution. Prerequisite: Metal. 509. *Mr. Ryba*

513. ADVANCED CHEMICAL METALLURGY I (3) Application of thermodynamics and kinetics to the heterogeneous metallurgical processes of oxidation, reduction, smelting, and refining. Prerequisites: Chem. 452, Metal. 301, 402, 404. *Mr. Healy*

514. Dislocation Theory (3) Self and interaction energies of dislocations and other defect structures; dislocation motions and their relation to mechanical properties. *Mr. Bitler*

515. Corrosion of Metals (3) Phenomena and theories of metallic corrosion; principles of alloy selection for engineering and structural uses in corrosive environments. *Mr. Read*

516. Flow and Fracture of Solids (3) Phenomenological and theoretical treatment of flow and fracture in solids. Prerequisites: Metal. 511, 514. *Mr. Hoke*

518. Heterogeneous Equilibria at High Temperatures (2-3) Treatment of high-temperature equilibria in metal and oxide systems involving crystalline, liquid, and gas phases. Prerequisite: Metal. 513. *Mr. Muan*

519. Advanced Chemical Metallurgy II (3) Application of thermodynamics and kinetics to precipitation of nonmetallic and metallic phases from liquid and solid metals at elevated temperatures. Prerequisite: Metal. 513. *Mr. Healy*

520. Foundry Metallurgy (3) Physical-chemical considerations of the liquid state, solidification, and the solid state as applied to casting of metals and alloys. Prerequisites: Metal. 511, 513. *Mr. Lindsay*

522. Solid-Phase Reactions in Metals (3) Mechanisms and rate determining factors in solid-phase reactions in metals; diffusion processes, nucleation theory, precipitations from solid solution, eutectoid decomposition and order-disorder phenomena. Prerequisites: Metal. 508, 511.

525. Metal Finishing (3) Metallic coatings and their metallurgical properties; theories and problems of application, utilization, and evaluation. Prerequisite: Metal. 515. *Mr. Read*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in metallurgical studies are listed under Mineral Sciences.*

METEOROLOGY (METEO)

Alfred K. Blackadar, *Head of the Department*
502A Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Blackadar, Hosler, Neuberger, and Panofsky.
Graduate Faculty, Associate Member: Associate Professor Dutton.

Candidates may specialize in a variety of areas such as aerosol and cloud physics, various phases of dynamic meteorology including turbulence and atmospheric circulation, atmospheric optics and electricity, macro- and microclimatology, synoptic meteorology, or meteorological instrumentation. The department also encourages interdisciplinary studies in such fields as agricultural meteorology, biometeorology, water resources, air pollution, and fluid mechanics.

Requirements for admission include mathematics through differential equations and

one year of college physics. Students with a strong background in mathematics, physics, or engineering may be admitted with deficiencies but must make up such deficiencies before they are admitted to candidacy for a degree.

METEOROLOGY (METEO)

400. Meteorology for Teachers (3)
401. Physical Climatology for Teachers (3)
402. Biometeorology for Teachers (2)
403. Science Projects in Meteorology (1)
404. Physics of Weather Forecasting (3)
411. Introduction to Synoptic Meteorology (3)
418. Introductory Physics of the Upper Atmosphere (3)
420. Tropical Meteorology (3)
430. Introduction to Synoptic Meteorology Laboratory (2)
431. Synoptic Meteorology Laboratory I (2)
432. Synoptic Meteorology Laboratory II (2-10)
433. Advanced Synoptic Analytical Techniques (3)
443. Physical Meteorology (3)
445. Hydrometeorology (3)
450. Applications of Statistics to Meteorology (3)
451. Introduction to Dynamic Meteorology (3)
452. Hydrodynamics of the Atmosphere (3)
453. Atmospheric Thermodynamics (3)
461. Theory of Meteorological Instruments (3)
472. Physical and Dynamic Climatology (3)
473. Introduction to Micrometeorology (3)
492. Meteorological Seminar (1-2)

500. Meteorological Seminar (1-3) Discussion of meteorological reports and papers; scientific outlook. Prerequisites: Meteo. 411, 451.

502. Selected Topics of Advanced Meteorology (1-3 per term) Current problems in meteorology. Prerequisite: a minimum of 15 credits in meteorology.

503. Atmospheric Turbulence (3) Atmospheric diffusion, heat conduction, friction, and evaporation; statistical properties of turbulence.

505. Bioclimatology (2) Climatic phenomena in their relation to life. Prerequisite: Meteo. 472.

506. Advanced Meteorological Analysis (2-6) Physical analysis of atmospheric phenomena; synoptic analysis of weather phenomena for advanced students.

507. Dynamic Oceanography (2) Physical properties of sea water; heat balance of the oceans; theory and observations of ocean currents, waves, and tides.

508. Physics of the Upper Atmosphere (2) Temperature distribution, composition, and electrical characteristics of the upper atmosphere; theories of aurora and light of the night sky.

509. Theoretical Climatology (2) Theory of latitudinal, annual, and diurnal temperature changes; theories of climatic changes, microclimate.

510. Cloud Physics (2) Current theories on phase changes in clouds and mechanisms responsible for precipitation; techniques of cloud modification and control.

551. Atmospheric Wave Motion (2) From classical and physical hydrodynamics to the numerical prediction of wave motion in a baroclinic atmosphere. Prerequisite: Meteo. 452.

552. Advanced Atmospheric Dynamics (2) Numerical prediction models, general circulation, thermal and gravitational tides in a spherical shell, and empirical orthogonal functions of statistical forecasting. Prerequisite: Meteo. 551.

553. Energetics of Atmospheric Motion (2) Theoretical investigation of the conversions of energy in the atmosphere; maintenance of the general circulation. Prerequisite: Meteo. 452.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in meteorological studies are listed under Mineral Sciences.*

MICROBIOLOGY (MICRB)

Robert W. Stone, *Head of the Department*
206 Patterson Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Casida, Cone, Dunne, Gentry, Lindstrom, Ludwig, Stone, and Zimmerman.

Graduate Faculty, Associate Members: Associate Professors Heist and Pootjes, Assistant Professor Tershak.

Specialized areas of study include microbial physiology, soil microbiology, food and industrial microbiology, microbial genetics, immunology, bacteriophage, and virology. There is opportunity for cooperative research with other departments in animal disease, food technology, and waste disposal.

Prerequisites for admission are 20 credits in chemistry including quantitative analysis and organic chemistry, 6 in physics, 8 in microbiology, and mathematics through calculus. Admission may be granted with deficiencies up to 8 credits, to be made up while pursuing graduate work.

MICROBIOLOGY (MICRB)

401. General Microbiology (4)
407. Problems in Microbiology (1-12)
410. Immunology and Serology (4)
411. Survey of Microbiology (1 per term)
412. The Bacterial Pathogens (4)
413. Soil Microbiology (3)
414. Food Microbiology (4)
416. Industrial Microbiology (4)
417. Epidemiology (2)
418. Bacterial Viruses (4)

507. Seminar (1 per term) Reports on current fields of research.

508. Bacterial Physiology (2-4) Contributions of environment, finestructure, and metabolism to the functioning cell. Prerequisite: Bioch. 402.

511. Special Topics in Microbiology (1-6)

512. Bacteriological Techniques (1-6) Practice in special laboratory techniques including manometry, tissue culture, and serology.

15. (V.Sc. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

16. Bacterial Genetics (2-4) Mechanisms of variation in microorganisms including mutation, adaptation, sexual recombination, transduction, and transforming factors. Prerequisite: 3 credits each in microbiology and genetics.

MINERAL ECONOMICS (MN EC)

John D. Ridge, *Head of the Department*
101 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professor Ridge, Associate Professor Gordon.
Graduate Faculty, Associate Member: Assistant Professor Harris.

The program in mineral economics prepares students for careers in mineral industries management, administration, or economic analysis and planning. Students may specialize in such areas as commodity analysis (fuels, metals, or nonmetals); resource economics (mineral policy or area studies); industrial economics (administration, market research, or financial matters); geostatistical and economic analysis of exploration and exploitation problems; or operations research and statistics (resource allocation, forecasting, or decision making).

Two related but distinctly different general programs for obtaining the M.S. and Ph.D. degrees are available, the one chosen depending on the education and practical experience of the candidate. One program is for students whose background is in the mineral industries and who wish to combine their scientific training with an understanding in depth of the methods by which economics can aid in solving problems in mineral industries exploration, exploitation, and processing. Requirements for admission to this program are 24 credits in chemistry, physics, mathematics, or statistics; 12 in the earth sciences; 9 in economics, mineral economics, commerce, business administration, or industrial management; and 6 in engineering subjects.

The second program is for students whose background is in economics and whose training and experience have given them an interest in applying their economic skills to the solution of mineral industries problems. Requirements for admission to this program are 12 credits in economics, mineral economics, and business administration; 9 in geological sciences; and 9 in mathematics and statistics.

The differences between the programs followed by these two groups of students will affect every aspect of their graduate programs—thesis work, required mineral economics courses, and elective selection. In all cases, the choices among courses and the emphasis within courses taken would be determined by the background of the student, the mineral industries-based program placing equal weight on the technical and economic aspects of mineral economics and the economics-based program placing more weight on the economic than on the technical features of the problems considered.

Students with deficiencies of 9 credits or fewer in either program may be admitted as degree candidates but will be required to make up such deficiencies without these credits being applicable toward the advanced degree.

In addition to the normal degree requirements of the Graduate School, candidates for the M.S. degree must write a thesis and defend it orally. Doctoral candidates in the mineral industries-based program must complete at least 15 credits in economics (including courses used for admission). Doctoral candidates in the economics-based program must complete at least 12 credits in the earth sciences or mineral engineer-

ing. The candidacy examination for the doctorate is entirely written, with the exception that the oral examination for the M.S. degree at Penn State may be used as the candidacy examination for the doctorate. If this is done, the M.S. examination will be more detailed and broader in scope than it would be for the M.S. alone. The comprehensive examination for the doctorate includes written examinations in the major and minor fields in addition to the oral examination required by the Graduate School.

MINERAL ECONOMICS (MN EC)

400. Seminar (1)
453. Nonmetallic Minerals (3)
483. The Metals and Their Ores (3)
484. Economics of Energy Resources (3)
486. Petroleum and Natural Gas Economics (3)
490. Mineral Valuation (3)
491. Analysis of Mineral Data (3)

500. Advanced Principles of Mineral Economics (3-6) Mineral history, research methods in mineral economics, applications of economic theory, mineral policy problems, economics of mineral exploitation, selected readings.

501. Advanced Studies in Mineral Commodities (3-6) Case studies of economic or industrial problems, or both, of selected mineral commodities. Prerequisites: 3 credits in Mn.Ec. 500 and at least 3 credits in Mn.Ec. 453, 483, 484, or 486.

502. Technologic Influences (3-9) Relationship of technologic advancements to economic development of the mineral industries. Prerequisite: 3 credits in Mn.Ec. 500.

505. Problems in Mineral Economics (3-12) Individual research involving library, laboratory, or field work to develop solutions to selected techno-economic problems of the mineral industries. Prerequisite: Mn.Ec. 500.

590. Mineral Economics Seminar (1 per term) Preparation and presentation of papers on advanced problems. Required each term in residence.

MINERAL ENGINEERING MANAGEMENT (M E M)

Boris J. Kochanowsky
Chairman of the Committee on Mineral Engineering Management
115 Mineral Industries Building

Degree Conferred: M.Eng.

Graduate Faculty, Senior Members: Professors Aplan, Carpenter, Essenhigh, Given, Griffith, Hummel, Kochanowsky, Lindsay, Miller, Niebel, Ridge, Slobod, Spicer, Stahl, Stefanko, Strong, Williamson; Associate Professors Farouq-Ali and Healy.

Graduate Faculty, Associate Members: Associate Professor Raphael; Assistant Professors Guild, Harris, Manula, and Schenk.

This program educates engineers for advancement into executive production management positions in the mineral and heavy construction industries, in development

and sales in manufacturing companies, and in consulting firms. It is designed to provide the knowledge, skills, and attitudes needed by persons to become innovators and responsible decision-making leaders. Participants are trained to create new designs, systems, and methods, and to plan, develop, and lead mineral industry organizations.

The content of all courses is based upon specific problems encountered in the mineral industries. These courses are offered by departments which have combined their resources to offer this interdisciplinary effort, namely: Departments of Mining, Petroleum and Natural Gas, Mineral Preparation, Mineral Economics, Material Science, and Industrial Engineering. Courses in each area may be selected by students and adapted to their individual interests. Seminars on integrated management problem solving are an essential feature of this program.

Programs emphasize quantitative methods (statistics, operations research, and computer applications); principles of economics applied in mineral industries (mineral economics, mineral commodities, cost and investment analysis, economic feasibility and profitability analysis, analysis involving intangibles); and management (finance, marketing, industrial and public labor relations, production, and operation management).

Students are required to present a scholarly written report on developmental study topics which may be suggested by industry.

For admission a bachelor's degree in one of six engineering branches of mineral industry (mining, petroleum, mineral preparation, metallurgy, fuel, and ceramics) or some other closely related field (industrial, civil, geological, mechanical, or chemical engineering) is required. The program will differ according to the specific goals of these branches and will be adapted to meet professional requirements.

MINERAL PREPARATION (MN PR)

FRANK F. APLAN, *Acting Head of the Department*
4 Mineral Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Aplan, Spicer, and Sun; Associate Professor Lovell.

Graduate Faculty, Associate Member: Associate Professor McLean.

The graduate program in mineral preparation not only prepares the student for a career in research or education but is also designed to give him the additional training needed to effectively pursue an industrial career as a specialist in mineral preparation methods. The mineral preparation engineer is concerned with the separation of valuable minerals from worthless rock by physical and chemical means as well as with the application of these methods to the recycle processing of used metals and minerals. He is also vitally interested in the control of air, land, and water pollution—particularly as they relate to mineral raw materials.

The student studies the physics and chemistry of particles—their creation, characterization, separation, and agglomeration; the surface chemistry of mineral particles; and chemical separations. This specialized knowledge is then integrated with the pertinent knowledge from the geological sciences to provide the basis for developing and understanding the practical means of separation of valuable material from that which is worthless.

Graduates with bachelor's degrees in ceramics, chemistry, chemical engineering, fuel science, the geological sciences, mathematics, metallurgy, mining, physics, or some branch of engineering are eligible for admission. Students with deficiencies may be required to make them up concurrently with their graduate studies.

MINERAL PREPARATION (MN PR)

401. Advanced Mineral Preparation Laboratory (1)
402. Mineral Preparation Seminar (1)
410. Coal Preparation (3)
420. Principles of Mineral Preparation Unit Operations (3)
421. Principles of Mineral Preparation Unit Operations (3)
425. Principles of Flotation (3)
426. Flotation Laboratory (1)
427. Modern Processes in Mineral Preparation (3)
430. Flowsheets of Mineral Preparation Plants (3)
457. Field Trip (1-2)

502. Froth Flotation and Agglomeration (3) Intensive study of theory and applications of froth flotation and agglomeration. Prerequisite: Mn.Pr. 420. *Mr. Sun*

504. Mineral Preparation Research (1-6 per term) Research work and study on specific problems in mineral preparation. Prerequisite: Mn.Pr. 410 or 420.

505. Gravity Processes and Miscellaneous Methods of Mineral Preparation (3) Intensive study of theory and applications of gravity, magnetic, electrostatic, centrifugal, and dense-media processes of mineral concentration. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

506. Mineral Preparation Plant Design (3-10) Layout, design, and selection of equipment for specific mineral preparation plant projects. Prerequisite: Mn.Pr. 420. *Mr. Spicer*

507. Chemical Processes of Mineral Preparation (3) Practice and theory of methods to upgrade ores by chemical treatment including roasting, solubility separations, surface phenomena, and reactions. Prerequisite: Mn.Pr. 420. *Mr. McLean*

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineral preparation studies are listed under Mineral Sciences.*

MINERALOGY AND PETROLOGY (MIN P)

Arnulf Muan
Head of the Department of Geochemistry and Mineralogy
204 Deike Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Barnes, Bates, Brindley, Burnham, Greig, Griffiths, Keith, Muan, Osborn, Roy, Wickman, and Wright; Associate Professors Dachille, Newnham, Rose, Thornton, Weber, and White; Mrs. Roy; Assistant Professor Suhr.

Areas of specialization include igneous, sedimentary, and metamorphic petrology, mineralogy, crystal chemistry, X-ray mineralogy, clay mineralogy, ore mineralogy, and application of statistics in the earth sciences.

The general requirements for admission are mathematics through integral calculus; chemistry through quantitative analysis; 10 credits in general physics; and 30 credits in geology, petrology, and mineralogy including microscopical petrography. Additional specific requirements must be fulfilled in most areas of specialization.

Students who have taken somewhat less than the indicated minimum of subjects may be admitted but must make up their deficiencies concurrently with their graduate studies.

MINERALOGY (MIN)

400.	(Cer.Sc. 400) NONMETALLIC CRYSTAL CHEMISTRY (2)	*Mr. Brindley*
402.	MINERALOGY AND PETROLOGY FOR TEACHERS (3)	*Mr. Thornton*
413.	SCIENTIFIC METHOD APPLIED TO THE EARTH SCIENCES (3)	*Mr. Griffiths*
463.	OPTICAL MINERALOGY (3)	*Mr. Gibbon*
483.	PETROLOGY (3)	*Mr. Thornton*
484.	PETROLOGY (2)	*Mr. Griffiths*

500. OPTICAL CRYSTALLOGRAPHY OF MINERALS (3) Optical methods, microscopic techniques, and measurement of optical constants of crystals; theory and application of the universal stage. Prerequisite: Min. 463. *Mr. Wright*

501. PETROLOGY (3-6) Microscopic study of rocks, emphasizing classification and genetic relationships. *Messrs. Thornton and Griffiths*

502. MINERALOGICAL PROBLEMS (3) Original study of some limited mineralogical or petrological problems.

505. MINERALOGY SEMINAR (1-2) Reading, presentation, and discussion of literature dealing with various phases of theoretical mineralogy. Topics are selected to meet the interests of the majority of the students.

°510. METAMORPHIC PETROLOGY (2-6) Detailed review of chemical, mineralogical, and structural changes that take place during metamorphism. Prerequisites: Min. 483, 484. *Mr. Burnham*

513. SCIENTIFIC METHOD IN GEOSCIENCE (3) Problem formulation, sampling designs, selection of variates, and comparison of techniques for analysis of aggregates.

514. STATISTICAL AND ELECTRONIC DATA PROCESSING PROCEDURES FOR GEOSCIENCE (3) Statistical analysis of experimental data using univariate and bivariate procedures.

520. STUDY OF ACCESSORY MINERALS (2-4) Detailed study of accessory (heavy) minerals; their significance in problems of provenance, petrogenesis, mineral stratigraphy, and paleogeography. Prerequisites: Min. 511, 513, 514. *Mr. Griffiths*

524. INTRODUCTION TO SEDIMENTATION (3) Prerequisites: Min. 483, 484.

525. IGNEOUS PETROLOGY (2-6) Origin, distribution, and composition of igneous rocks. Prerequisites: Gchem. 513; Min. 483, 484, 500, 527. *Mr. Burnham*

526. PROBLEM-SOLVING IN GEOSCIENCE (3) Multivariate statistical analysis, decision-making, operations research, and systems analysis in geoscience.

527. IGNEOUS AND METAMORPHIC MINERALOGY (3) Structural and compositional variations of minerals in igneous and metamorphic rocks.

530. (Cer.Sc. 530) STRUCTURE, PROPERTIES, AND OCCURRENCE OF CLAY MINERALS (2-5) Structure analysis and identification of clay minerals; mineral transformations and behavior; occurrence, genesis, and petrography of fine-grained sediments. *Mr. Brindley*

NOTE: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mineralogical studies are listed under Mineral Sciences.*

° Credits to be arranged, 2-4 per term.

MINING ENGINEERING (MNG E)

ROBERT STEFANKO, *Head of the Department of Mining*
118 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Kochanowsky and Stefanko, Associa Professor Hardy.

Graduate Faculty, Associate Member: Assistant Professor Manula.

Areas of specialization which may be followed in research and course work inclu mine property valuation and economics of mining engineering (ore estimation, co analysis and control, budgeting), mechanization and mine plant (unit operatio materials handling, continuous mining, power supply), development and exploitati methods (mine planning and layout, design of systems), mine management, produ tion engineering and operations research (time study, standards, job rating, operatio analysis), environmental control (gas and dust technology, ventilation, air conditio ing, hygiene, illumination, safety), and rock mechanics (stress analysis, roof a ground control, penetration, fragmentation).

A bachelor's degree in mining engineering or a related engineering field is r quired for admission. Students may be required to make up deficiencies in their ar of specialization. Certain basic, related courses outside the department may be a proved as part of the major.

MINING (MNG)

402. MINE PLANT DESIGN (3)
410. MINING ENGINEERING ANALYSIS (3)
411. MINE SYSTEMS ENGINEERING (3)
422. MINE VENTILATION AND AIR CONDITIONING (3)
431. ROCK MECHANICS (3)
451-452. ADVANCED MINING ENGINEERING I AND II (1 each)

510. PLANNING, PROGRAMMING, AND CONTROL OF PRODUCTION AND OPERATION (Over-all planning, design, and selection of equipment; programming and sched ing of mining operations; statistical control of costs and production indices. P requisite: Mng. 513.

513. MINE COST ANALYSIS (3) Nature of mining costs, their analysis and contr depreciation and depletion, capital and operating costs, budgets, records.

514. MINE OPERATIONS ANALYSIS (3) Application of operations research tec niques in determining optimal design and operating policies for mine manageme Prerequisite: Mng. 411.

515. MINE SYSTEMS SIMULATION (3) Principles and practices of probabilistic a deterministic simulation in the analysis of operating systems related to mills a mines. Prerequisites: Mng. 411, Cmp.Sc. 401.

531. RHEOLOGICAL AND STRENGTH CHARACTERISTICS OF ROCKS (3) Properties rocks and their determination; failure theories; brittle to ductile transition; rhe logical behavior. Prerequisite: Mng. 431.

532. SPECIAL TOPICS IN ROCK MECHANICS (1-3) Behavior of rock under sta loading; underground stress instrumentation; experimental stress analysis; desi of mine openings; theories of subsidence.

533. Post-Yield Mechanics of Rock (3) Theory of inelastic, time-independent rock behavior; selected applications to drilling, blasting, mine opening, pit slopes, and ore passes. Prerequisite: Mng. 431.

541. Theory of Rock Penetration (3) Behavior of rock under dynamic loads intended to penetrate; basic energy relations; application of theory to drilling and other penetration. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

542. Theory of Rock Fragmentation (3) Behavior of rock under dynamic loads intended to fragment; physical chemistry of explosives; detonation; theory of blasting; design of drill rounds. Prerequisites: E.Mch. 13, Mng. 30, Phys. 203.

543. Strata Control Engineering (3) Theoretical considerations; convergence, abutments, subsidence; rockbursts; underground support systems; design of mine openings. Prerequisite: Mng. 431.

545. Rock Mechanics Instrumentation (3) Strain gage circuitry, transducers, electro-hydraulic servo installations, and integrated strain and force measuring systems as applied to rock mechanics. Prerequisite: Mng. 431.

580. Mining Engineering Research (1-3 per term) Supervised research on a specific problem involved in mining science or technology.

590. Graduate Mining Seminar (1 per term) Preparation and presentation of formal papers on problems of an advanced nature in mining engineering. Required once during each year of residence.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in mining studies are listed under Mineral Sciences.*

MUSIC (MUSIC)

Robert W. Baisley, *Head of the Department*
232 Music Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Senior Member: Assistant Professor Brinsmaid.

Graduate Faculty, Associate Members: Professor Baisley, Assistant Professor Case.

The Master of Arts degree program is designed to provide a wide range of studies in music. The student may emphasize one of the following areas, or may elect a program including work in all of them: theory, performance, history, and composition. Admission requires completion of a recognized music major. A thesis is required of all M.A. candidates in the program.

The Master of Fine Arts degree program is planned to provide professional emphasis. Students will specialize in either performance or composition. In addition to credit requirements, admission to the program is contingent upon department certification of the candidate's competence. According to the area of specialization, auditions or submission of manuscripts are required. Arrangements for this can be made by the student with the department. While 48 credits are listed as a minimum requirement, it should be noted that the amount of course work necessary may exceed the minimum according to the needs and background of the student involved.

Students who lack the recommended upper-class courses in music may be required to take additional course work without receiving graduate credit.

The department sponsors musical activities, and candidates for both degrees are required to participate in positions of responsibility.

MUSIC (MUSIC)

407. Piano Literature (3)
410. Music of the 20th Century (3)
411. A Chronological Study of String Literature (3)
412. Music of the Baroque Period (3)
413. Music of the Middle Ages (3)
414. Music of the Renaissance (3)
415. Hymnology (3)
416. Studies in American Music (3)
*‡429. Vocal Style (3) Fee $80.
433. The Singing Voice (3)
454. Harmonic Analysis (3)
455. Form and Analysis (3)
456. Counterpoint (3)
457. Composition (3)
459. Orchestration and Arranging (3)
466. Advanced Conducting (3)
467. Opera Workshop (1-6)
468. Advanced Chamber Music (1-6)

*‡501. Advanced Harpsichord (3) Instruction in harpsichord playing; preparation for recital performance. Fee $100.

*‡503. Advanced Orchestral Instruments (3) Study, repertoire building, and recital performance. Fee $80.

*‡511. Advanced Piano (3) Piano literature of all periods for public performance. Fee $80.

*‡520. Voice (3) Study, repertoire building, and recital performance. Fee $80

*‡531. Advanced Organ (3) Study, repertoire building, and recital performance. Prerequisite: 4 credits of Music 31 and/or 38. Fee $100.

543. Modern Harmony (3) Harmonic writing based on 20th century practice with attention to traditional idioms that serve as foundation.

544. Analysis and Analytic Procedures (3) Analytic studies for the development of effective understanding of modern musical syntax.

557. Symphonic Structure (3) Survey of the evolution and application of the forms used in symphony, sonata, concerto, string quartet, and related works. Prerequisite: Music 369.

*‡558. Free Composition (3) Composition: vocal and instrumental, standard or modern idioms.

567. The Literature of the Orchestra (3) The suite, symphony, tone poem and overture from the point of view of appreciation, form, and orchestration.

* Course may be scheduled only by conference with the head of the department.
‡ May be repeated for a total of 18 credits.

570. History of Musical Instruments (3) A survey of the historical and morphological aspects of musical instruments.

571. Performance Practices (3) Analysis and performance of music of various periods based on manuscripts, documents, and other source materials.

598. Music Seminar (1-3) Seminar in the history, art, and science of music, with readings, discussion, and performance.

MUSIC EDUCATION (MU ED)

Frances M. Andrews, *Head of the Department*
266 Chambers Building

Degrees Conferred: D.Ed., M.Ed.

Graduate Faculty, Senior Members: Professors Andrews and Dunlop.
Graduate Faculty, Associate Members: Professor Campbell, Assistant Professor Deihl.

Graduate programs offer work in the various areas of public school music, including general, instrumental, and vocal/choral music on the elementary and secondary levels; preparation is also offered for supervisory or administrative positions, college teaching, and research. It is possible to include work from a number of these areas in the M.Ed. or D.Ed. programs.

Completion of a recognized music education major, or program leading to certification, is a prerequisite for admission to the M.Ed. or D.Ed. programs. The latter also requires a minimum of two years of teaching experience.

MUSIC EDUCATION (MU ED)

415. Workshop in Selected Music Education Studies (1-6)
446. The Elementary Music Specialist (3)
462. Pedagogy of Theory (3)
468. The Teaching of Piano (3)
469. Band and Orchestra Technique (3)
470. Choral Technique (3)
471. Teaching Marching Band (2)
472. Wind Instrument Materials (2)
474. Tests and Measurements in Music (3)
475. Objectives and Problems in Elementary Music Education (3)
480. Choral Program in the Secondary School (3)
487. Children's Songs and Records (3)

500. Music Education Seminar (3-6) Problems of various phases of music education, both instrumental and vocal; research and literature dealing with these problems.

501. Problems and Projects in Music Education (1-6) Independent work on special topics of music education pertinent to the development of curricula, methods, and materials in music education. Prerequisite: 12 graduate credits in education (including music education).

525. Proseminar: Graduate Study in Music Education (1-3) Bibliography; location and evaluation of reference materials; organization, form, style in preparing music education research reports and other papers.

569. Present-Day Trends in Instrumental Music (3-6) New methods and materials for band, orchestra, and ensembles.

572. Instrumental Pedagogy (3-6) Research problems in band and orchestra. Prerequisite: Mu.Ed. 54 or practical experience.

573. The Materials of Appreciation (3) Examination of written and recorded materials and appropriate techniques for developing appreciation of music, grades one through twelve.

574. Present-Day Trends in Music Education (3-6) Present-day music education materials and methods (elementary and secondary levels) in relation to modern educational philosophy; emphasis on practical problems presented by members of the class. Prerequisites: Mu.Ed. 48, teaching experience.

575. The Junior High School Music Curriculum (3) Instructional materials, procedures, curricular and extracurricular activities, integration with other subjects.

576. Music Supervision (3) Current educational procedures in training music supervisors.

581. Contemporary Music Education (3) Prerequisite: 20 credits at the graduate level including Mu.Ed. 500.

582. Theory and Projects in Musical Learning (3-6) Experimentation and self-instructional techniques involved in musical learning projects. Prerequisite: Inst.M. 435.

594. Pedagogy of Ear Training (3) Materials and methods for training the listener to grasp, understand, and write what is heard from melody to four-part harmony. Prerequisite: 12 credits in ear training and/or harmony.

598. Internship in Music Performance Techniques (1-6) Internship in selected school or music performance situations other than those in the district where the graduate student is employed.

NUCLEAR ENGINEERING (NUC E)

Warren F. Witzig, *Head of the Department*
231 Sackett Building

Degrees Conferred: Ph.D., M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Diethorn, Foderaro, Jacobs, Palladino, and Witzig; Associate Professors Kenney, Klevans, Remick, and Schultz.
Graduate Faculty, Associate Members: Assistant Professors D'Ardenne and Jester.

A student may specialize in reactor physics, neutron and radiation transport phenomena, thermal and mechanical design of reactors, supervision and utilization of research reactors, nuclear materials, fuel management, or reactor instrumentation and

control. Admission requires a bachelor's degree in engineering or in the physical sciences. Students who have not had appropriate undergraduate courses in modern physics and differential equations will be required to schedule them.

NUCLEAR ENGINEERING (NUC E)

400. Nuclear Engineering Special Topics (1-12)
401. Introduction to Nuclear Engineering (3)
405. Nuclear and Atomic Properties of Matter (3)
407. Statistical and Transport Descriptions of Matter (3)
410-411. Nuclear Engineering (3 each)
415. Radionuclear Applications (3)
420. Radiological Safety (2)
430. Design Principles of Reactor Systems (3)
431. Synthesis of Nuclear Systems (2)
440-441. Nuclear Engineering Laboratory (3 each)
490. (E.E. 490) Introduction to Plasma Theory (3)

501. Reactor Engineering (3) Reactor controls, shielding of nuclear reactors, stress analysis of reactor materials, power cycle analysis, breeding, and advanced design considerations. Prerequisite or concurrent: Nuc.E. 411.

502. Reactor Engineering Laboratory (1-5) Reactor experiments devised to acquaint the student with reactor technology. Prerequisite or concurrent: Nuc.E. 411.

503. Thermonuclear Engineering (3) Binary fusion reactions; microscopic and macroscopic phenomena in a completely ionized gas; electromagnetic confinement; design, operation, and diagnostics of experiments. Prerequisite: Math. 452.

505. Reactor Instrumentation and Control (3) Neutron-detecting instruments and circuits; in-core power instrumentation; reactor control principles; control mechanisms; operational control problems. Prerequisite: Nuc.E. 411.

506. Two-Body Kinematics (3) Conservation laws of classical and quantum mechanics and their application to interactions between two bodies. Prerequisite: Math. 72.

507. Interaction of Radiations with Matter (3) Theory of the processes by which gamma rays, neutrons, and charged particles interact with electrons, atoms, and nuclei. Prerequisite: Nuc.E. 506.

508. Radiation Shielding (2) Radiation sources in reactor systems; attenuation of gamma rays and neutrons; deep penetration theories; Monte Carlo methods. Prerequisite: Nuc.E. 507.

509. Radiation Damage in Solids (2) Production of defects by high energy particles; nature of defects; diffusion and annealing in solids; macro property changes. Prerequisite: Nuc.E. 507.

511. Nuclear Reactor Materials (3) Philosophy, selection, technology, use, economics, and performance of materials of major interest in nuclear power reactors today. Prerequisite: Nuc.E. 411.

520. Reactor Analysis (3) Physical principles and mathematical methods of reactor analysis. Prerequisite: Nuc.E. 410.

521-522. Neutron Transport Theory (3 each) Derivation of Boltzmann equation for neutron transport; techniques of approximate and exact solution for the monoenergetic and spectrum regenerating cases. Prerequisite: Nuc.E. 410 or Phys. 406.

525. Nonlinear Reactor Kinetics (3) Intrinsic response of reactors to extreme reactivity insertions, mathematical models, physics of feedback coefficients, analysis of behavior of burst reactors. Prerequisite: Nuc.E. 411.

550. Special Topics in Nuclear Engineering (1-12) Theoretical studies in nuclear engineering with or without associated experimental work. Prerequisites: Math. 72, Phys. 406.

590. (E.E. 590) Theory of Plasma Waves (3) Solutions of the Boltzmann equation; waves in bounded and unbounded plasmas; radiation and scattering from plasmas. Prerequisite: Nuc.E. 490.

591. (E.E. 591) Plasma Theory (3) Advanced topics in kinetic theory, fluctuation theory, microinstability, and turbulence. Prerequisite: Nuc.E. 590.

PETROLEUM AND NATURAL GAS ENGINEERING (PNG E)

C. Drew Stahl
Head of the Department of Petroleum and Natural Gas
25 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Slobod and Stahl, Associate Professors Bissey and Burcik.
Graduate Faculty, Associate Members: Associate Professors Donohue and Farouq-Ali.

Areas of specialization include experimental and theoretical studies of water flooding and the newer methods for displacing oil from porous media, methods for calculating reservoir performance, scaled laboratory studies of reservoir phenomena, and drilling and well completion problems.

Students who expect to enter graduate study in this field with a degree in another major should present 6 credits in geology, 15 in engineering science, and credit for mathematics through integral calculus. A limited number of deficiencies may be made up after admission.

Certain closely related courses outside the department may be counted as petroleum and natural gas credits toward the degree.

PETROLEUM AND NATURAL GAS (P N G)

410. Applied Reservoir Engineering (3)
420. Applied Reservoir Analysis (3)
421. Reservoir Engineering (3)
450. Drilling Design and Production Engineering (3)
475. Petroleum Engineering Design (3)
480. Production Process Engineering (3)
481. Natural Gas and Gasoline Plants (2)
485. Engineering in Secondary Recovery (3)
493. Engineering Evaluation of Oil and Gas Properties (3)
495. Formation Evaluation (3)

510. Flow of Homogeneous Fluids Through Porous Media (3) Applications of vectors, separation of variables, conformal mapping, Laplace transform to describe steady and unsteady state flow in porous media.

511. Material Transfer in Porous Media (3) Diffusion and convective mixing in porous media; solution of the partial differential equations involved; difference methods; mathematical model, viscous instabilities.

512. Reservoir Engineering (3-6) Mathematical analysis of complex reservoir behavior and combination drives; numerical methods for the solution of behavior equations; recent developments. Prerequisite: P.N.G. 510.

514. Optimization of Petroleum Recovery Processes (3) Optimum search methods, linear programming, nonlinear programming, dynamic programming, application to waterflooding, depletion drive, steam injection, gas cycling, miscible displacement. Prerequisite: P.N.G. 410.

515. Advanced Oil Recovery Techniques (3) Advanced oil recovery techniques including water-flooding, in-situ combustion, steam injection, hot-water injection, and miscible-phase displacement.

517. Case Studies of Secondary Recovery (1-3) Interpretation and critical analysis of production and injection characteristics of typical water flood operations. Prerequisite: P.N.G. 515 or 485.

519. Design of Thermal Recovery Projects (3) Suitability of reservoirs for thermal oil recovery; case histories; design of in-situ combustion and steamfloods; thermal stimulation; shale oil recovery. Prerequisite: P.N.G. 515.

520. Phase Relations in Reservoir Engineering (3) Phase relations as applied to condensate and retrograde condensate reservoirs and to other problems in petroleum production.

525. Special Topics in Petroleum Engineering (2-6)

530. Natural Gas Engineering (1-3) Flow in producing or storage reservoirs; gas well testing; transmission systems; storage cycle; current developments. Prerequisite: P.N.G. 481.

*535. Seminar (1-3)

540. Special Studies in Petroleum Engineering (1-3) Supervised short study performed in the field, library, or laboratory covering any approved topic related to petroleum engineering.

Note: *Courses in the use of X-ray diffraction, electron microscopy, and spectroscopy in petroleum and natural gas studies are listed under Mineral Sciences.*

PHILOSOPHY (PHIL)

John M. Anderson, *In Charge of Graduate Programs in Philosophy*
422 Boucke Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

* Credits to be arranged, 1 per term.

Graduate Faculty, Senior Members: Professors Anderson, Finch, Freund, Hausman, Johnstone, Kockelmans, Mourant, and Rosen; Associate Professors Gotshalk and Lingis.

Graduate Faculty, Associate Members: Associate Professors Price and Tsugawa, Assistant Professors Flay and Kennington.

A thorough grounding in the history of philosophy is required of all students. Specialization is possible in areas (such as aesthetics, metaphysics, ethics and social philosophy, logic), in movements of thought (such as rationalism, empiricism, idealism, phenomenology, existentialism), or in any of the major figures in the history of western philosophy. Specialization is also possible in a joint program with the Department of Mathematics in logic and the foundations of mathematics. Undergraduate preparation to the extent of a strong minor is advisable.

The department may waive the requirement of a thesis for an M.A. candidate.

PHILOSOPHY (PHIL)

406. Medieval Philosophy (3)
408. Studies in Social and Political Philosophy (3)
410. Studies in Greek Philosophy (3-6)
411. Studies in Modern Philosophy (3-6)
412. Studies in Contemporary Philosophy (3)
413. Philosophy of Literature (3)
414. Aesthetic Theory (3)
417. Nineteenth Century Philosophy (3)
419. Philosophical Backgrounds of American Thought (3)
420. Philosophy of History (3)
421. Classics of Scientific Method (3)
422. Philosophical Logic (3)
426. Metaphysics (3)
427. Advanced Ethics (3)
428. (Math. 428) Logical Theory (3)
429. Semantics: Philosophy of Language and Symbolism (3)
430. Philosophical Problems (1-9)
435. Religion and Science (3)

500. Ethics: Historical and Systematic (2-6) Critical study of some phase of ethical theory, or of some period of the history of ethics.

504. Social and Political Philosophy (3-6) Critical study of basic problems in their historical and functional setting.

505. Philosophy of Western Religion (3-6) The consideration of contemporary western religious concepts in terms of their Graeco-Judean traditions.

506. Seminar in Ancient Philosophy (3-6) Study of one or more important men or movements in ancient philosophy.

507. Seminar in Medieval Philosophy (3-6) Study of one or more important men or movements in medieval philosophy.

508. Seminar in Modern Philosophy (3-6) Men and movements in philosophy from the Renaissance through the 19th century.

509. Seminar in Contemporary Philosophy (3-6) Men and movements in 20th century philosophy.

511. Principles of Experimental Inference (3-6) Science as controlled inquiry; types of scientific procedures in formal, physical, and sociocultural science.

512. Advanced Topics in Philosophy of Science (3-6) Crucial problems in the theory of science and scientific method.

514. Seminar in 19th Century Philosophy (3-6) Study of a philosopher or philosophical movement of the 19th century.

515. Philosophical Method (3-6) Methods proposed by classical and contemporary thinkers for reaching philosophical conclusions: deductive, inductive, dialectical, pragmatic, intuitive.

516. Seminar in Aesthetics (3-6) Problems and theories in the nature of art.

526. Seminar in Metaphysics (3-6) Formulation and analysis of metaphysical problems in the various fields of philosophy.

530. Philosophy Research Seminar (1-12) Study of selected philosophical problems with an emphasis on techniques of philosophical research.

550-551. (Math. 550-551) Foundations of Mathematical Logic (3 each) The nature of logical basis of mathematics; critical examination and development of the basic parts of logical calculus. Prerequisite: Math. 480 or Phil. 428.

554. (Math. 554) Logic and Metamathematics I (3) Completeness, Löwenheim-Skolem, Herbrand, and compactness theorems; first-order theories; categoricity, elimination of descriptions; decidability; algebraic and geometric applications. Prerequisite: Phil. 428.

556. (Math. 556) Recursion Theory (3) Recursive functions; normal form, enumeration and separation theorems; partial recursive functions, recursion theorems; special recursive functions; alternate formulations; related topics. Prerequisite: Phil. 428.

557. (Math. 557) Logic and Metamathematics II (3) Arithmetization; Gödel and Tarski incompleteness theorems; undecidability results; Gentzen-type systems and consistency results. Prerequisites: Phil. 554, 556.

PHYSICAL EDUCATION (PH ED)

Benjamin H. Massey
Associate Dean for Graduate Study and Research
270 Recreation Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Buskirk, Conger, Coombs, Gross, Harnett, Massey, Mendez, Thiel, and van der Smissen; Associate Professors Lucey and Nelson.

Graduate Faculty, Associate Members: Associate Professors Kollias, Lundegren, Magnusson, and Nicholas; Assistant Professors Morehouse and Skinner.

Areas of specialization include (1) physiology of exercise (physical conditioning, physical fitness, and performance stress); (2) kinesiology (applied anatomy and biomechanics); (3) measurement and test construction; (4) cultural bases of physical education and sport (history, philosophy, and sociological foundations); (5) motor learning; (6) organization and administration (methods and materials, curriculum construction, intramurals, and interscholastics); and (7) recreation and parks.

Admission to the M.S. program requires a major in physical education or its equivalent in comparable course work. Especially desirable is course work in mathematics plus a concentration on the physical, biological, behavioral, or social sciences, depending upon the intended areas of specialization. Admission to the M.Ed. program requires a minimum of 18 credits in health and physical education plus 18 credits in education and educational psychology combined, including practice teaching. A year or more of field experience is recommended.

Admission to doctoral study requires the master's degree or its equivalent, demonstrated research ability in the form of a thesis or published research, and acceptable performance on the Aptitude Test of the Graduate Record Examination or other specified tests. A student who has earned a master's degree in recreation and parks and meets the above requirements may enter a doctoral program in physical education with specialization in recreation and parks.

See also "Recreation and Parks."

HEALTH EDUCATION (HL ED)

411. Principles and Methods of Teaching Safety Education (3)
456. Advanced Techniques in School Community Health Education (3)
498. Special Projects (1-6)

501. Health Implications in the Growth and Development of School Children (3) Child growth and development emphasis for teachers; medical inspection and examination; preschool program; early habit formations; behavior problems; cooperation of parents, teachers, and children. Prerequisite: Hl.Ed. 215.

PHYSICAL EDUCATION (PH ED)

400. Adaptive Physical Education (3)
452. Analysis of Physical Education Activities for the Elementary School (3)
455. Statistical Methods in Health, Physical Education, and Recreation (3)
456. Physical Fitness Appraisal (3)
460. Methods and Principles of Athletic Coaching (3)
480. Advanced Anatomy and Physiology, Applied (3)
483. Principles of Body Mechanics (3)
484. Kinesiology (3)
489. Intramural Athletics (3)
491. Organization and Administration of Health and Physical Education in Schools (3)

500. (Rc.Pk. 500) Individual Study and Research Projects (1-10) Prerequisite: Ph.Ed. 530.

530. (Rc.Pk. 530) Research Techniques in Health and Physical Education and Recreation (3)

531. Research in Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 530.

532. Tests and Measurements in Physical Education (3) Critical study of tests and measurements available in physical education; methods of constructing and evaluating new tests and measurements. Prerequisite: Ph.Ed. 490.

534. Studies in Curriculum Construction in Physical Education (3) Principles and methods of curriculum building in physical education; different psychological and educational points of view, organizing a course of study committee, making units of instruction.

535. Modern Foreign Systems of Physical Education (3) Comparative analysis of national and local programs and systems of physical education in foreign countries. Prerequisites: Ph.Ed. 534, 595.

550. Seminar in Health and Physical Education (1-6) An in depth analysis of current problems confronting the profession.

560. Administrative Problems of Physical Education in Schools (3) Solutions to problems emerging from the administration of physical education in schools, fitting physical education into the school's schedule, awards and budgets. Prerequisite: Ph.Ed. 491.

565. Neuromuscular Performance (3) Integrative action of the neural and muscular systems in effecting human movement with emphasis on motor performance. Prerequisites: Ph.Ed. 480, 490.

575. Motor Performance of the Handicapped (3) Motor performance of physically handicapped and mentally retarded. Activities and therapeutic exercises for the formulation of individualized programs. Prerequisites: Ed.Ser. 409, E.E.C. 410.

576. Internship in Adapted Physical Education (3) Supervised internship in recreational, educational, or clinical situations; assessment of motor performances, evaluation of activities, and staff conference participation.

581. Biomechanics (3) Kinetic and kinematic analyses of human motion utilizing electromyography and stroboscopic-photographic techniques. Prerequisite: Ph.Ed. 480.

582. Advanced Kinesiology (3) Analysis of sports movements utilizing cinematography, electronic devices, and related research instruments.

583. Special Topics in Biomechanics (1-6) Critical review of current research in biomechanics, culminating in individual research projects. Prerequisite: Biol. 443.

585. (Phsio. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Phsio. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Phsio. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Ph.Ed. 585.

595. Philosophy of Health and Physical Education and Recreation (3) Prerequisite: Ph.Ed. 491 or Rc.Pk. 465.

PHYSICAL SCIENCE (PH SC)

John P. McKelvey
Chairman of the Committee on Physical Science
101 Osmond Laboratory

Degrees Conferred: D.Ed., M.Ed.

The M.Ed. program, designed to meet the needs of secondary school science teachers, requires at least 24 credits chosen from chemistry, physics, astronomy, mathematics, earth sciences, and biological sciences, including at least 9 each in chemistry and physics. In addition, a minor of at least 6 credits in education is required. The student must also complete a satisfactory term paper on a subject approved by the committee.

For admission to either the M.Ed. program or the D.Ed. program, the student is expected to have completed two years of college chemistry, one year of college physics at a level requiring calculus, mathematics through differential equations, and 18 credits in appropriate education and psychology courses.

For the D.Ed. degree, the student is required to complete 24 credits in physical science, including chemistry, earth sciences, mathematics, and physics, which *may* (but are not required to be) in courses designed specifically for teachers. He is expected, beyond this, to complete 36 credits in standard 400- and 500-level courses, which *may not* be courses designed primarily for teachers; of these, 12 credits must be in chemistry, 12 in physics, and 12 in science and mathematics courses approved by the student's doctoral committee. In addition, 15 credits in education courses and 15 credits of thesis research are required. The student's selection of science courses should include at least 6 credits in experimental physics or chemistry.

A limited amount of work can be done during summer terms or off-campus, but a candidate must plan to be on the University Park Campus for at least four consecutive terms after he has been accepted as a D.Ed. candidate. The student will be required to take a candidacy examination after having completed about 30 credits of graduate study, and a comprehensive examination after having completed his required course work. He must also present and defend a thesis, which may be either an experimental study in physics or chemistry, or an investigation of a problem in the teaching of physical science.

See also Earth Sciences, Chemistry, Mathematics, and Physics.

PHYSICS (PHYS)

David H. Rank, *Head of the Department*
101 Osmond Laboratory

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Bleuler, Cutler, Frankl, Gibbons, Henisch, Herman, Kazes, McCubbin, McKelvey, Müller, Polo, Pratt, Rank, Skudrzyk, Webb, and Wiggins; Associate Professors Atwater, Barsch, Feuchtwang, Kendall, Strother, Vedam, Weber, and Whitfield.

Graduate Faculty, Associate Members: Associate Professors Eastman, Fleming, Freed, Schumacher, and Thwaites; Assistant Professors Graetzer, Lochstet, Madjid, McCammon, and Shaw.

Graduate instruction and research opportunities are available in visible and infrared spectroscopy, laser physics, solid state, field emission, thermionic emission, photoelectric emission, acoustics, low-temperature physics, nuclear physics, physics of high polymers, and of carotenoids, electron spin resonance of solids, and various phases of theoretical physics.

A bachelor's degree in physics or an allied field is required for admission to the M.S. and Ph.D. programs. Students who lack some of the usual upper-class undergraduate courses in physics may be requested to take additional course work without degree credit.

For admission to the M.Ed. program a student is required to have completed one year of general college physics plus two acceptable intermediate courses in physics, mathematics through integral calculus, and 18 credits in education and related psychology. The program requires at least 18 credits in physics, including Phys. 400 and 458 and approved laboratory work such as Phys. 470; at least 3 credits each in chemistry and mathematics; and at least 6 credits in education.

PHYSICS (PHYS)

400. Intermediate Electricity and Magnetism (4)
402. Electronics (4)
406. Nuclear Physics (3)
410. Introduction to Quantum Mechanics (3)
412. Introduction to Solid State Physics (3)
419. (A.M. 419) Theoretical Mechanics (3)
420. Classical Thermodynamics (2)
421. Thermal Physics (2)
433. Mechanics and Fluid Physics for Teachers (3)
435. Electricity and Magnetism for Teachers (3)
436. Optics for Teachers (3)
437. Heat, Wave Motion, and Sound for Teachers (3)
439. Elementary Survey of Modern Physics for Teachers (3)
441. Demonstration Experiments for Teachers (3)
443. Intermediate Acoustics (3)
454. Atomic and Nuclear Physics (3)
456. Atomic and Molecular Physics (3)
457. Experimental Physics (1-2 per term)
458. Intermediate Optics (4)
461. (A.M. 461) Theoretical Mechanics (3)
467. Intermediate Electricity and Magnetism (3)
470. Special Topics (1-9)

507. Thermodynamics (3) Classical thermodynamics and thermodynamics of irreversible processes. Prerequisites: Phys. 420, Math. 417.

509. Physics Seminar (1-3 per term) Topics from current research.

512-513. Introduction to the Quantum Theory of Solids (3 each) Energy band theory; electrical, optical, and magnetic properties; lattice dynamics; transport theory. Prerequisites: Phys. 412, 517.

517. Statistical Mechanics (3) Classical and quantum statistics; statistical thermodynamics; the Boltzmann transport equation; methods illustrated with applications to physical problems. Prerequisites: Phys. 507, 561.

525. Methods of Theoretical Physics (3) Vector and tensor analysis; generalized coordinate systems; matrices and linear vector spaces of finite and infinite dimensionality; calculus of variations. Prerequisite: advanced calculus.

526. Methods of Theoretical Physics (3) Continuation of Phys. 525: complex variables; Hilbert space; Green's functions; orthogonal functions and boundary value problems. Prerequisite: Phys. 525.

530. Theoretical Mechanics (3) Newtonian mechanics; Lagrange's equations, Hamilton's principle; Hamilton's equations; coupled systems; waves in strings, central field problem; rigid bodies; elasticity; hydrodynamics.

532. Advanced Theoretical Mechanics (3) Least action principle; canonical transformation; Lagrange and Poisson brackets; Hamilton-Jacobi equations; classical theory of field. Prerequisite: Phys. 530.

533. Theoretical Acoustics (3) Vibrating systems; transmission of disturbances through elastic and viscoelastic media. Prerequisite: Phys. 530.

550. (A.M. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

553-554. Nuclear Physics (3 each) Discussion and theoretical interpretation of basic experiments involving atomic nuclei and nuclear radiations. Prerequisite: Phys. 562.

557. Electricity and Magnetism (3) Electro- and magnetostatics, Maxwell's equations, boundary value problems, electric and magnetic properties of material media.

558. Advanced Electricity and Magnetism (3) Energy and momentum in the field, radiation theory, classical relativistic electron theory. Prerequisite: Phys. 557.

560. Research Problems (1-10) Introduction to research through individual assignments.

561-562. Quantum Mechanics (3 each) The basic theory of wave and matrix mechanics, approximation methods, applications. Prerequisite: Phys. 530.

563-564. Advanced Quantum Mechanics (3 each) Relativistic wave equations, quantum field theory, other advanced quantum theoretical topics. Prerequisite: Phys. 562.

571. Atomic Physics (3) Experimental basis of modern physics; atomic spectra and structure, nuclear phenomena.

575. Special Topics (1-3 per term) Theoretical studies in any field of modern physics with or without associated experimental work. Prerequisite: Phys. 456.

PHYSIOLOGY (PHSIO)

Richard D. Schein
Chairman of the Committee on Physiology
211 Whitmore Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Almquist, Anderson, Anthony, Barron, Bortree, Buskirk, Flipse, Hale, Mendez, Morgan, Mueller, Pike, and H. Schraer; Associate Professors Amann, Houlihan, Hymer, Mortimore, and Smyth; Assistant Professor R. Schraer.

Graduate Faculty, Associate Members: Associate Professors Kollias, Nicholas, and Wickersham; Assistant Professors Cornwell, Dunson, Eberhart, Jefferson, McCarl, Rhoades, and Skinner; Mr. Neely; Mrs. Pubols.

This is an interdisciplinary program designed to enable students to obtain an integrated series of courses encompassing both the fundamentals of physiology and advanced training in a specialized area.

Graduate instruction in physiology is under the direction of a program committee composed of graduate faculty representing several departments or groups actively participating in the physiology program, including the areas of animal science, biochemistry, biophysics, and zoology, and the Human Performance Research Labora-

tory. The instructional staff is composed of the program committee as well as faculty in those departments offering graduate courses in various areas of specialization in physiology. The program, including courses, laboratory experience, and original research, is designed for completion in three to four academic years.

The entering student who lacks adequate preparation in chemistry, mathematics (through calculus), physics, or biological science must make up the deficiency early in his graduate program. All candidates (master's and doctoral) must complete a general basic laboratory course in physiology (combined cellular, mammalian, and comparative) before choosing an area of specialization. Possible areas of specialization are cellular and subcellular physiology, environmental physiology, endocrinology, applied physiology (human performance), physiology of nutrition and metabolism, neurophysiology, or comparative physiology. The graduate committee for majors shall be appropriately represented by members of the physiology program committee and those of the area of specialization who shall have the responsibility and jurisdiction for determining the course program and research acceptable in satisfying degree requirements.

The following courses are available for physiology majors, and their descriptions may be found under the offerings of several departments: Anthy. 401; A.Ntr. 401, 402; Bioch. 401, 402, 417, 436, 437, 438, 501, 517, 519, 520, 521; Biol. 401, 471, 475, 538, 539, 541, 575, 583; Bphys. 473, 474, 475, 580, 588; D.Sc. 427, 431, 512, 515, 521; Ent. 411; F.N. 452, 457, 459, 552, 557; Micrb. 401, 508; Psy. 402, 403, 503.

The following courses in physiology and biochemistry are offered at The Milton S. Hershey Medical Center: Anat. 505, 510, 535; Bchem. 502, 503, 513, 523, 540, 570, 590; Phsio. 520, 521, 525, 530, 550, 570, 590. Descriptions of these courses may be found on pages 245 to 248.

PHYSIOLOGY (PHSIO)

501. Seminar (1 per term)

510. Special Topics in Physiology (1-6)

571. (Biol. 571) Animal Physiology (2) Physiology and fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Biol. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Biol. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Biol. 574) Animal Physiology Laboratory (1-6) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisites: Phsio. 571, 572. Prerequisite or concurrent: Phsio. 573.

585. (Ph.Ed. 585) Applied Physiology (3) Presentation of current thinking on physiological mechanisms with emphasis on physically active man. Prerequisite: 3 credits in physiology at the 400 or 500 level.

586. (Ph.Ed. 586) Research Methods in Applied Physiology (3) Historical and current procedures for evaluation of cardio-pulmonary function, metabolism, and thermal balance in man; lecture, demonstration, and student laboratory. Prerequisite: 3 credits in physiology at the 400 or 500 level.

588. (Ph.Ed. 588) Special Topics in Applied Physiology (1-6) Critical discussion and evaluation of current research in applied physiology. Prerequisite: Phsio. 585.

PLANT PATHOLOGY (P PATH)

JAMES TAMMEN, *Head of the Department*
211 Buckhout Laboratory

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bloom, Boyle, Kneebone, Lewis, Mills, P. E. Nelson, R. R. Nelson, and Tammen; Associate Professor Wood; Assistant Professor Merrill.

Graduate Faculty, Associate Members: Adjunct Professor Hyre; Associate Professor Schisler; Assistant Professors Lukezic and Wuest.

Plant pathology is the study of disease in plants and concerns the dynamic interaction between the plant, the causal agent (bacteria, fungi, viruses, nematodes, etc.), and their environments. A student prepares for a professional career in research, teaching, extension, or industry through advanced studies of the principles of plant infection, the physiology of disease in plants, the ecology of root diseases, the nature and inheritance of disease resistance in plants, epidemiology, ecology, and physiology of air pollution injury to plants, or plant disease control by biological or chemical means. A student also may specialize in the nature and control of the diseases of forest trees, agronomic or horticultural crops, and commercial mushrooms. Advanced studies in applied mycology, related to the production of the commercial mushroom, also may be taken. Modern, well-equipped laboratories, controlled environment facilities and greenhouses, and well-developed field research areas are available for graduate study.

For admission a student must present 42 credits in the natural sciences, including a minimum of 15 credits in the plant sciences and a minimum of 15 credits in mathematics, chemistry, or physics. It is strongly recommended, but not required, that an applicant have 3-6 credits in a foreign language. Students with a strong background in agronomy, biochemistry, biophysics, botany, forestry, genetics, horticulture, or microbiology are usually well prepared for advanced study in plant pathology.

PLANT PATHOLOGY (P PATH)

408.	PLANT PATHOLOGICAL TECHNIQUES (3)	*Mr. Bloom*
410.	INTERMEDIATE PLANT PATHOLOGY (1)	*Mr. Wuest*
411.	DISEASES OF ORNAMENTAL AND FLORICULTURAL PLANTS (2)	*Mr. P. E. Nelson*
412.	ADVANCED FOREST PATHOLOGY (2)	*Mr. Merrill*
413.	DISEASES OF FIELD CROPS (2)	*Mr. Lukezic*
414.	DISEASES OF FRUIT AND VEGETABLE CROPS (2)	*Messrs. Bloom and Boyle*
420.	PLANT PATHOGENIC BACTERIA (3)	*Mr. Lukezic*
422.	INTRODUCTION TO PLANT VIROLOGY (3)	*Mr. Boyle*
429.	PHYTONEMATOLOGY (3)	*Mr. Bloom*
430.	HISTORY OF PLANT PATHOLOGY (2)	*Mr. Merrill*

501. CLINICAL PLANT PATHOLOGY (3) Diagnosis and prognosis of disease; observe and evaluate the implementation of control practices. Prerequisite: P.Path. 408. *Mr. Wuest*

518. SPECIAL PROBLEMS (1-12) The prosecution of an assigned problem under the guidance of a staff member. Throughout the year as arranged. By appointment.

531. PLANT PATHOLOGY SEMINAR (1 per term) Selected topics of current research, history, and contemporary trends in plant pathology. *Mr. Tammen*

540. PLANT DISEASE CONTROL (3) Principles of plant disease control, including theoretical considerations involved in control by chemical and nonchemical means. *Mr. Cole*

541. Physiology of Plant Disease (3) Physiology of the diseased plant, including the host response to the pathogen and parasitic properties of the pathogen. Prerequisite: Biol. 443. *Mr. Lukezic*

542. Epidemiology of Plant Diseases (4) Disease development in populations of plants, with emphasis on the impact of environment and control practices on rate of development. Prerequisite: 9 credits in plant pathology. *Mr. Wood*

543. Pathogen Variation and Host Resistance (3) Mechanisms and implications of genetic variation in plant pathogens related to breeding for disease resistance in plants by genetic means. *Mr. R. R. Nelson*

544. Pathological Plant Anatomy (2) Structural manifestations occurring in diseased plants. Prerequisites: Biol. 407, P.Path. 408. *Mr. P. E. Nelson*

560. Principles of Plant Pathology (3) Open-ended discussions of concepts of plant pathology, with emphasis on their interrelationships and their significance to the science. *Mr. R. R. Nelson*

POLITICAL SCIENCE (PL SC)

Robert S. Friedman, *Head of the Department*
129A Sparks Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Albinski, Aspaturian, Atwater, Brown, Friedman, Hennessy, Masters, McGeary, Monat, Mowitz, and Silva; Associate Professor Kochanek.

Graduate Faculty, Associate Members: Assistant Professors LaPorte, Leduc, and Petras.

M.A. candidates will be comprehensively examined in American politics, comparative politics, international relations, political philosophy, or public administration. Candidates offering the thesis plan will also offer course work in one other of these substantive fields, or from among selected empirical theory-methodology courses. Candidates offering the non-thesis plan will offer course work in two of the above six fields. Six credits in a minor field is required of all M.A. candidates. Ph.D. candidates will be comprehensively examined in three of the five substantive fields, in one subfield, and in a minor field or fields. Course work in empirical theory and scope and methodology is required. Competence must be demonstrated in approved skills selected from among foreign languages, statistics/mathematics, and computer science. Admission requires the equivalent of at least 12 credits in political science.

POLITICAL SCIENCE (PL SC)

401. Political Behavior (3) *Messrs. Keynes and Masters*
403. The Legislative Process (3) *Messrs. Keynes and Masters*
411. American Political Theory (3) *Messrs. Eisenach and Ricci*
412. International Organization: Economic and Social Welfare Functions (3) *Mr. Atwater*
413. Government and Politics of the Soviet Union (3) *Messrs. Aspaturian and Atwater*
414. Foreign Policy of the Soviet Union (3) *Mr. Aspaturian*
415. International Organization: Political and Security Functions (3-6) *Messrs. Aspaturian, Atwater, and Sheikh*

416. International Law (3) *Mr. Sheikh*
417. American Local Government and Administration (3) *Messrs. Leduc and Lee*
419. Bureaucracy and Public Policy (3) *Messrs. Lee and Monat*
421. Modern Political Theory (3) *Messrs. Eisenach and Ricci*
425. Government and Politics of the American States (3) *Mr. Hennessy*
426. Political Parties (3) *Miss Silva*
427. Political Opinion (3) *Miss Silva and Mr. Hennessy*
431. Ancient and Medieval Political Theories (3) *Messrs. Eisenach and Ricci*
433. (L.M.R. 433) The Law of Labor-Management Relations (3)
441. Anglo-American Legal Systems (3) *Messrs. Eisenach and Keynes*
442. American Foreign Policy (3) *Mr. Atwater*
444. Government Regulations (3) *Mr. Hennessy*
445. Administrative Law (3) *Mr. Boyan*
447. Constitutional Law: The Federal System (3) *Miss Silva*
448. Constitutional Law: First Amendment Freedoms (3) *Mr. Boyan*
450. Canadian and Australian Politics and Foreign Policies (3) *Mr. Albinski*
451. Comparative Political Analysis (3) *Mr. Albinski*
453. Political Processes in Underdeveloped Systems (3) *Messrs. Kochanek, LaPorte, Petras, and Sheikh*
456. Politics and Institutions of Latin-American Nations (3) *Mr. Petras*
457. International Politics of Latin America (3-6) *Mr. Petras*
458. Governments and Foreign Policies of the Far East (3-6) *Mr. Kochanek*
459. Government, Politics, and International Relations of South Asia (3) *Mr. Kochanek*
460. Liberal and Democratic Political Theory (3) *Messrs. Eisenach and Ricci*
461. Authoritarian and Elitist Political Thought (3) *Messrs. Eisenach and Ricci*
462. Marxist and Socialist Political Theory (3) *Messrs. Eisenach and Ricci*
473. Constitutional Law: Civil Rights (3)
499. Foreign Study in Government (2-6)

500. Political Power (3-6) Subject to be announced.

505. Executive Power (3-6) *Miss Silva and Mr. Monat*

509. Scope and Method of Political Science (3-6)

512. Comparative Political Systems (3-9) *Messrs. Albinski, Kochanek, and Petras*

513. Seminar in Comparative Political Parties (3-6) Nature, function, organization, and leadership of parties; party systems, political culture, voting, and the institutional framework. *Mr. Albinski*

515. International Politics (3-6)

516. Seminar in International Relations Theory and Methodology (3) A detailed analysis of major traditional and contemporary theory-building efforts and contemporary research techniques and orientations in international relations.

517. International Organization (3-6) *Messrs. Aspaturian and Atwater*

518. Latin-American Politics (3-6) Forces which shape the quest for power and the process by which public policies are determined.

521. Modern Democratic Political Theory (3-6)

522. Comparative Foreign Policies (3-6) Major policies of selected nations which bear upon the search for international peace and security. *Mr. Aspaturian*

523. Soviet Political Behavior (3) Forces which shape rivalries for power; decision-making processes; areas of agreement and dissent. *Mr. Aspaturian*

524. Foreign Policies of the Soviet Bloc (3-6) Major policies, the decision-making process, and the impact upon component members and external rivals for power. *Mr. Aspaturian*

527. Politics and Legislative Behavior (3-6) Social factors which shape and determine the attitudes and decisions of American legislators and legislative bodies. *Mr. Masters*

528. Politics and Education (3) Social forces which shape the educational system and determine national, state, and local educational policies. *Mr. Masters*

529. Federal Systems (3-6) Features of the American federal system compared with those of other nations using the federal form. *Mr. Monat*

530. Public Law (3-6) The nature of law and its role in modern society. *Miss Silva*

531. Marxism and Political Socialist Theories (3) A systematic analysis and appraisal of major premises and deductions. *Mr. Aspaturian*

532. Empirical Political Theory (3-6) The impact of scientific method upon traditional political thought.

546. Judicial Process (3) Court functions in the political process; sources and limits of judicial power; perceptions of the judicial role; judicial decision-making. Prerequisite: 12 credits in political science.

571. Theory of Public Administration (3-6) The role of the executive in modern government; the objectives of public administration; theories of administrative organization and practice. *Mr. Mowitz*

572. International Development Administration (3-6) The execution of foreign policies through national and international public and private organizations. *Mr. LaPorte*

573. Comparative Public Administration (3-6) Administrative systems of selected nations on a functional basis; relationship between culture, economic and social systems, and public administration. *Mr. LaPorte*

574. Seminar in the Administration of United States Foreign Affairs (3) Effect of cross-cultural operations on the normal process of administration of United States foreign affairs. *Mr. LaPorte*

575. Government Manpower Management (3) Government personnel systems; current trends and problems; essentials of recruitment, classification and pay, ratings, supervision, training, and discipline.

576. Government Fiscal Decision-Making (3) The role of the executive in fiscal planning; budget preparation; expenditure control; tax assessment and collection; investment of public funds. *Mr. Monat*

577. Organization and Systems Management (3) Principles of government organization; management surveys; work measurement; methods of achieving efficiency and economy. *Mr. Mowitz*

578. Public Planning and Development Administration in the United States (3) Public planning agencies and their functions; essentials of effective planning and zoning; current trends and problems. *Mr. Leduc*

580. Internship in Public Administration (6)

POULTRY SCIENCE (PTY SC)

KENNETH GOODWIN, *Head of the Department*
105 Weaver Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Bressler, Buss, Goodwin, Hale, and Mueller; Associate Professor Hicks.

Graduate Faculty, Associate Member: Associate Professor MacNeil.

The department offers two types of graduate programs. Students interested in genetics or physiology may participate in these programs with thesis research in the Department of Poultry Science. (See "Genetics" and "Physiology" for admission requirements.)

The programs in behavior, food technology, management, and nutrition consist of a major in poultry science and a minor in one or more other fields of science. Admission requirements include 30 credits in biology, chemistry, mathematics, and physics.

POULTRY SCIENCE (PTY SC)

401. (Biol. 401, Psy. 401) ANIMAL BEHAVIOR (3) *Mr. Hale*

402. SPECIAL TOPICS (3-12)

405. POULTRY PRODUCTION TECHNOLOGY (3) *Mr. Mueller*

502. ADVANCED POULTRY NUTRITION (2-4)

503. ADVANCED POULTRY FARM MANAGEMENT (2-4) *Mr. Bressler*

504. POULTRY MEAT AND EGG TECHNOLOGY (2-6) Prerequisites: Fd.T. 202 and 2 additional credits in poultry science. *Messrs. Mueller and MacNeil*

505. RESEARCH IN POULTRY SCIENCE (1-10 per term) Prerequisite: 9 credits in poultry science.

582. (Biol. 582, Psy. 582) RESEARCH IN ANIMAL BEHAVIOR (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale and Schein*

NOTE: *See Animal Science and Food Technology under "Other Elective Graduate Courses." Also see Food Science.*

PSYCHOLOGY (PSY)

MERRILL E. NOBLE, *Head of the Department*
117 Burrowes Building

Degrees Conferred: Ph.D., D.Ed., M.S.

Graduate Faculty, Senior Members: Professors Carpenter, Cofer, Ford, Greenhill, Guthrie, Hale, Hall, Harris, Hoffman, Leibowitz, Lundy, Mitzel, Noble, Palermo, Smith, Thevaos, Trumbo, and Warren; Associate Professors Draguns, Freeman, Gorlow, Schipper, Seibel, Sherif, Stern, and Urban.

Graduate Faculty, Associate Members: Professor Taylor; Associate Professors Dubin, Piers, and Whaley; Assistant Professors Cornwell, Galbraith, Ratliff, Sample, and Thomas.

Graduate instruction and research opportunities are available in the following areas of psychology: general experimental, physiological and comparative, measurement and statistics, social and personality, developmental, clinical, industrial and business, engineering and human factors.

Special research and training facilities include the Penn State Anechoic Chamber, the University Computation Center, the Animal Behavior Laboratory, the Psychology Clinic, the Division of Counseling, and the Special Education unit.

Requirements for admission include a broad undergraduate preparation, a junior-senior scholastic average of B, a minimum of 12 credits in psychology, a satisfactory graduate student rating on the Miller Analogies Test, and the Graduate Record Examination (General). Applicants with master's degrees will have their admission evaluated with emphasis on the quality of their graduate programs.

PSYCHOLOGY (PSY)

401. (Biol. 401, Pty.Sc. 401) Animal Behavior (3) — *Mr. Hale*
402. Sensation and Perception (3) — *Mr. Freeman*
403. Introductory Physiological Psychology (3) — *Mr. Warren*
404. Learning and Motivation (3) — *Mr. Hall*
405. The Experimental Psychology of Visual Perception (3) — *Mr. Leibowitz*
406. Experimental Social Psychology (4)
408. Comparative Psychology (2-4) — *Mr. Warren*
409. Laboratory in Operant Conditioning (1-3) — *Mr. Hoffman*
410. History of Psychology (3) — *Messrs. Freeman and Leibowitz*
412. Abnormal Psychology (3) — *Mrs. Kirchner and Mr. Draguns*
413. Biographical Psychology (3) — *Mr. Harris*
415. Intermediate Experimental Design (3)
417. Social Psychology (3) — *Mrs. Sherif and Mr. Sample*
425. Child Psychology (3) — *Mr. Whaley*
426. Adolescence (2-3) — *Mr. Harris*
430. Verbal Behavior and Verbal Learning (3) — *Mr. Cofer*
431. Industrial Psychology (3) — *Mr. Smith*
432. Introductory Engineering Psychology (3) — *Mr. Schipper*
433. Psychology of Occupational Behavior (2) — *Mr. Dubin*
434. Information-Processing Laboratory (1-3)
436. Mental Health in Schools (3)
437. Psychology of Adjustment (3) — *Mr. Gorlow*
438. Theory of Personality (3) — *Mr. Gorlow*
440. Psychology Projects (1-6)
441. Industrial Motivation and Morale (3)
445. (I.F.S. 445) Development Throughout Adulthood (3) — *Mr. Britton*
450. (Ed.Psy. 450) Principles of Measurement (3)
452. Laboratory in Sensory Processes (2-4) — *Mr. Freeman*
453. Neuroanatomy Laboratory (1)
455. Physiological Psychology Laboratory (3)
474. Psychology of Exceptional Children (3) — *Miss Piers*
482. Introduction to Clinical Psychology (3) — *Mr. Galbraith*

500. Seminar: Introduction to Graduate Study (2-6) Required of all new graduate majors in psychology.

501. Advanced Psychology (3) Comprehensive study of general psychology. Prerequisite: 9 credits in psychology.

503. Physiological Psychology (2-6) Correlations between structure and func tion of nervous system and human consciousness; laws and theories in fields o sensation, attention, association, affection, and thought. Prerequisite: 9 credits i psychology. *Mr. Warre*

505. Research Problems in Psychology (1-15) Prerequisite: 12 credits in psy chology.

509. Seminar in Conditioning and Learning (3-9) Prerequisite: Psy. 404 o Ed.Psy. 421.

511. Seminar in Contemporary American Psychology (2-3) Current system or schools of psychology with comparative study and critical analysis; points o view as presented by recognized leaders. Prerequisite: 9 credits in psychology.

515. Advanced Statistics in Psychology and Education (3) Correlation theor and methods, discriminant function, and factor analysis; applications to menta test theory. Prerequisite: Psy. 415 or Ed.Psy. 506.

516. Seminar in Quantitative Models (3-9)

518. Projects in Experimental Psychology (2-4) Individual experimental proj ects; seminars on experimental design and instrumentation.

527. Statistical Inference and Experimental Design (3) Probability theory sampling distributions, analysis of variance and covariance, analysis of trend, non parametric statistics, experimental design. Prerequisite: Psy. 415 or Ed.Psy. 506.

529. (C.D.F.R. 529) Seminar in Child Development (1-6) Readings and re ports on recent findings in child development. Prerequisite: 6 graduate credits i child development, child psychology, or educational psychology, plus 3 in statistics

533. Seminar in Engineering Psychology (2-9) Design and operation of ma chines, man-machine allocation, the man-machine interface, displays, system-design decision-making, image evaluation, and motor behavior. Prerequisite: Psy. 432.

535. Developmental Psychology (2-3) Developmental principles and concept applied to psychological processes, with special reference to the experimental lit erature.

536. (C.D.F.R. 536) Research Methods in Child Development (3) Prerequi sites: 6 credits in child development and a course in statistics.

537. Seminar in Industrial Psychology (1-9) Prerequisite: Psy. 431. *Mr. Smit*

538. Psychology of Personnel Development (3) Industrial training in relatio to psychological learning theory and experimental findings. Prerequisite: Psy. 43 or Ed.Psy. 421. *Mr. Smit*

539. Seminar in Motivation and Emotion (3-9) Systematic status of instinct drive, motive, will, purpose; methodology and results of physiological, experimental and clinical investigation of basic drives. *Mr. Ha*

540. Seminar in Clinical Problems (1-6) Contemporary psychological theory research, and methodology in relation to clinical psychology. Prerequisites: Psy 542, 560.

541. Personality Theory (3-4) Contemporary theories of personality; relevan research. Prerequisite: Psy. 438.

542. Psychopathology (3-4) Theories of pathological behavior with reference t clinical and experimental data. Prerequisite: Psy. 412.

545. Seminar in Verbal Learning and Verbal Behavior (3)

549. (C.D.F.R. 549) Theories of Child Development (2-3) Historical background of the major theories concerning child development and behavior and their application. *Mr. Harris*

555. Theory and Practicum in Clinical Assessment (3-9) Theoretical issues and research in clinical assessment with special reference to administration and interpretation of testing procedures and clinical interviewing. Prerequisites: Psy. 541 or 542, and a course in measurement.

558. Clinical Child Psychology (3-9) Psychopathology of childhood; theories of etiology; diagnosis and treatment. Prerequisites: Psy. 555, 561. *Miss Piers*

559. The Individual Psychological Examination (3) Demonstrations and practice in widely used ability and aptitude tests; psychological report writing. Prerequisites: 15 credits in psychology and a course in measurement.

560. Practicum in Clinical Methods (1-6) Supervised practice in the Psychology Clinic, including assessment, therapy, report writing, and staff participation. Prerequisite: Psy. 555.

561. Clinical Practicum with Children (1-6) Diagnosis and counseling of child-parent problems of learning and adjustment. Prerequisites: Psy. 425, 426, 555.

569. Advanced Theory and Practicum in Counseling and Psychotherapy (3-9) Theoretical issues, research, and practicum experience in psychotherapy.

571. Seminar in Social Psychology (3-9) Historical development of theory and methods; determinants and principles of complex social or interactional behavior; contemporary problems and research.

580. Theory and Construction of Attitude Scales (3) Measurement of social, political, commercial, and industrial attitudes; questionnaire designs. Prerequisite: 3 credits in statistics.

581. Experimental Study of Primate Behavior (3) Taxonomy of contemporary species of primates; ontogeny of learning, perception, and affective behavior; interspecies comparisons of behavior.

582. (Biol. 582, Pty.Sc. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work. *Messrs. Hale, Schein, and Warren*

590. Problems in Clinical Research (1-6) Prerequisite: Psy. 415.

591. Seminar on Teaching Psychology (1-3) Objectives and content of psychology; organization and presentation of material; teaching aids and techniques.

PUBLIC ADMINISTRATION (PUB A)

Robert J. Mowitz
Director of the Institute of Public Administration
302 Engineering E

Degree Conferred: M.P.A.

Graduate Faculty, Senior Members: Professors Friedman, Masters, Monat, and Mowitz.
Graduate Faculty, Associate Members: Associate Professor Riew; Assistant Professors LaPorte, Leduc, Petras, and Westby.

All candidates take a core program and may concentrate through electives in one of the following areas: general public administration, public planning administration, comparative and international administration, urban administration, human resources administration, and natural resources administration.

Candidates for admission ordinarily will have at least 12 hours of undergraduate credit in the social sciences. Candidates for the degree may be required to take some courses without graduate credit in order to complete a major designed for their professional needs.

RECREATION AND PARKS (RC PK)

Benjamin H. Massey
Associate Dean for Graduate Study and Research
270 Recreation Building

Degrees Conferred: M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Coombs, Gross, Massey, and van der Smissen; Associate Professor Nelson.

The graduate program is designed to prepare students for administrative, supervisory, research, and teaching positions in public recreation and park systems, in colleges and universities, in voluntary agencies, and in institutions.

The program is oriented to meet the specific needs and research interests of the candidate. Areas of specialization include (1) recreation and park administration, including outdoor recreation planning, (2) recreation program supervision and administration, including recreation for special groups, (3) camping, outdoor education, and outdoor interpretive services, and (4) professional education.

The master's degree may be earned in the major field of recreation and parks. At the doctoral level, attention is called to the programs available in the physical education major.

For admission to the graduate program, a bachelor's or master's degree is required in recreation, park administration, or in a related field, e.g., forestry, landscape architecture, sociology, psychology, physical education, education, fine arts.

RECREATION AND PARKS (RC PK)

420. Outdoor Recreation (3)
425. Interpretive Services (3)
430. Outdoor Education (3)
440. Camp Administration (3)
456. Recreation Program Organization (3)
461. Community Recreation (3)
465. Administration of Recreation and Parks (3)
470. Metropolitan Park Management (3)
475. Recreation for Special Groups (3)
498. Special Projects (1-6)

500. (Ph.Ed. 500) Individual Study and Research Projects (1-10) Prerequisite: Rc.Pk. 530.

515. Program Development and Supervision (3) Critical analysis of the individual, political, and societal determinants of recreation programming; demonstration projects; evaluative procedures, research functions in programming. Prerequisite: Rc.Pk. 456.

520. Seminar in Camp Administration (3) Values inherent in the camp experience; critical analysis of philosophical choices and sponsor objectives as influencing program development. Prerequisite: Rc.Pk. 230 or 430.

530. (Ph.Ed. 530) Research Techniques in Health and Physical Education and Recreation (3)

533. Recreation Studies, Surveys, and Appraisals (3) Advanced research procedures related to special recreation and park problems. Prerequisites: Rc.Pk. 530 and 3 credits in statistics.

540. Public Recreation Lands (3) Planning recreation lands; legislation, financing, intergovernmental coordination to acquire and develop open space land, urban recreation and park master plan.

550. Seminar in Recreation and Parks (1-6)

560. Administrative Problems of Recreation and Parks (3) Special problems of recreation and park departments; legal powers and liability; departmental organization, financing, personnel policies, and staff development. Prerequisite: Rc.Pk. 465.

590. Philosophical and Social Bases of Recreation (3) Philosophical and social bases of recreation; analysis of critical issues of recreation for philosophical and social implications.

REGIONAL PLANNING (R PL)

Frank B. Burggraf, Jr.
Chairman of the Committee on Regional Planning
318 Sackett Building

Degree Conferred: M.R.P.

This program emphasizes the training of technically competent planners and the development of their awareness of the importance of the social, political, economic, and cultural goals of the citizens in a region. Requirements for admission include at least one course each in sociology or political science; physical geography, geology, or soils; and engineering or architectural graphics, plus 6 credits in mathematics.

REGIONAL PLANNING (R PL)

400-401. Principles of Regional Planning (3 each)
410. Planning Programs (3)
420. Theory and Methodology of Regional Planning (3)
440. Problems in Community and Regional Planning (1-9)

510. Planning Techniques and Analysis I (3) Regional socio-economic structure, problems, and factors in planning; data collection, analysis, and implications.

520. Planning Techniques and Analysis II (3) Interaction of man and environment; land and water resources in regional planning; environmental factors as planning parameters.

530. Planning Techniques and Analysis III (3) Physical, aesthetic, and cultural design aspects of planning. Cultural value judgments and environmental design.

540. Problems in Regional Planning (1-9) Planned individual projects involving library, laboratory (studio), or field work.

600. Thesis.

610. Thesis.

RURAL SOCIOLOGY (R SOC)

Macklin E. John
Head of the Department of Agricultural Economics and Rural Sociology
6-A Weaver Building

Degrees Conferred: Ph.D., M.S., M.Agr.

Graduate Faculty, Senior Members: Professors Bealer, Brown, and John.
Graduate Faculty, Associate Member: Assistant Professor Willits.

In all programs emphasis is on a comprehensive understanding of the various facets of societal organization pertinent to the rural sector. While scope is encouraged, there are available certain areas of special interest and research: consumer behavior; instigated social change; community structure; human resource development; migration; adolescent behavior; the culture of poverty; the ecology of rurality in industrialized, urbanized society. All students are required to have training in sociological theory, statistics, and research methods.

The entering student in the master's program should have as prerequisites 3 credits in rural sociology, 3 credits in sociology, and 3 additional credits in either field. If he does not have these prerequisites, he may take them at this university during the early part of his master's program.

RURAL SOCIOLOGY (R SOC)

401. Special Topics in Rural Sociology (1-6)
402. Consumer Behavior and the Agricultural Industry (3)
444. Rural Life in an Industrial Society (3)
452. Rural Organization (3)
459. Rural Social Psychology (3)

501. Development of Rural Sociology (2) Historical development with emphasis on American rural sociology.

502. Advanced Rural Sociology (3) Structure and functioning of rural society; evaluation of theoretical systems.

510. Rural Migration (2) Rural migration research and theory; application to governmental and community problems.

512. National Farm Organizations (2) National farm organizations as social systems. Prerequisite: R.Soc. 452.

513. Sociology of Consumer Behavior (2) Sociological theory and research pertaining to consumer behavior.

514. Values in Rural Society (2) Values as dynamic forces in rural society.

515. Extension Organization and Methods (2) Agricultural and home economics extension as a social system, with emphasis on techniques of organization and program development.

516. Change in Rural Society (2) Social change in rural society, emphasizing prediction and control of the change process.

551. Rural Sociology Seminar (1-6) Prerequisite: 6 credits in rural sociology, sociology, or psychology.

SANITARY ENGINEERING (S E)

Benjamin A. Whisler
Head of the Department of Civil Engineering
212 Sackett Building

Degrees Conferred: M.S., M.Eng.

Graduate Faculty, Senior Members: Professors Kountz, Nesbitt, and Whisler.

Graduate Faculty, Associate Members: Associate Professor McDonnell, Assistant Professor Unz.

The entering student should be a graduate in sanitary engineering from an accredited college of engineering, but a graduate in civil engineering may obtain the M.S. in sanitary engineering by taking a limited amount of extra undergraduate work in subjects appropriate to the sanitary engineering field. A student wishing to obtain a Ph.D. degree may major in civil engineering with emphasis on sanitary engineering.

The following courses offered by the Department of Civil Engineering are appropriate for students majoring in sanitary engineering (course descriptions are given under Civil Engineering): C.E. 471, 472, 571, 572, 573, 574, 575, 576, 577, and 580. Appropriate courses offered by other departments include: Ag. 400; Bioch. 425, 436; Biol. 410; Chem. 405; Cmp.Sc. 402; Geol. 452; Meteo. 445; Micrb. 401, 414; Nuc.E. 420; and Pl.Sc. 419.

SCHOOL PSYCHOLOGY (S PSY)

Joseph L. French
Chairman of the Committee on School Psychology
119 Education and Psychology Center

Degrees Conferred: D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Carriker, French, Harris, Noble, Rabinowitz, and Thevaos; Associate Professor Smith.

Graduate Faculty, Associate Members: Associate Professor Snyder, Assistant Professors Cardon and Ratliff.

This interdisciplinary program based on courses in psychology, educational psychology, special education, and related fields is designed to produce dually oriented professionals who are well prepared in both psychology and education. The objective is to develop a psychologist who is interested in and knowledgeable about schools. The school psychologist must utilize his professional skills and his knowledge about

children and youth to make contributions which are meaningful to and utilized by teachers. The development of competencies needed by a fully qualified school psychologist requires at least the education represented by a doctoral degree. Other areas of study related to school psychology, such as clinical psychology, general educational psychology, counselor education, and child development, are found in other departments of the University.

Practicum facilities include the speech pathology and audiology out-patient service, the Reading Center, the Psychology Clinic, and the Demonstrtaion School for mentally retarded children. Facilities for work with children are available through other departments also.

An undergraduate major in psychology or in education of exceptional children is expected of applicants, but students with fewer than 15 credits in psychology may be admitted with limited deficiencies to be made up concurrently with their graduate studies. Requirements for admission include a minimum junior-senior scholastic average of B and a satisfactory scholastic aptitude rating. Applicants with a master's degree will be required to show more than a minimum success in graduate study, including at least one-third of their graduate credits of "A" quality.

SCHOOL PSYCHOLOGY (S PSY)

500. Professional Issues in School Psychology (1-3) Orientation to the field through study of unique problems, current issues, ethical and legal matters, unique cases, and research projects.

504. Practicum in School Psychology (1-6) Clinical experience with children under supervision in a variety of settings requiring service including practice in synthesizing data and observations.

508. Internship in School Psychology (1-10) Long term placement in settings providing work for school psychologists with children, parents, teachers, administrators, and service agencies under supervision.

SECONDARY EDUCATION (SEC ED)

John Withall, *Head of the Department*
164 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors Fagan, Fowler, Remaley, and Withall; Associate Professors Heimer and Pendered.

Graduate Faculty, Associate Members: Associate Professors Kozak, Searles, and Shemick; Assistant Professors Dupuis and Ribble.

Graduate degree programs emphasize the advanced preparation of classroom teachers, special supervisory personnel, and curriculum specialists. Candidates for the D.Ed. and Ph.D. degrees with a major in secondary education must meet all the requirements, including residence, described in the earlier sections of this bulletin. For admission to the D.Ed. program at least 18 credits in education and related psychology are required.

Candidates for the D.Ed. degree with a minor in secondary education must take a minimum of 15 course credits approved in advance by the head of the Department of Secondary Education. When course work has been completed more than five years

prior to admission to the D.Ed. or when it is transferred from another institution, the head of the department will determine its suitability for any part or all of the 15 hours required.

Candidates for the M.S. degree with a major in secondary education will fulfill all the requirements for that degree, including a thesis, which are listed previously in this bulletin. Candidates with a minor in secondary education must have 6 credits in education approved by the head of the Department of Secondary Education. In general, candidates for the M.Ed. in secondary education must have 18 approved undergraduate credits in education and psychology including practice teaching in an area appropriate to the major, and aptitude for and interest in advanced professional preparation. Applicants are urged to have had at least two years of successful teaching experience before completion of the degree requirements. Although candidates are required to specialize in secondary education, they are encouraged to increase their general education in the social sciences, the behavioral sciences, and the humanistic foundations.

The M.Ed. degree may be earned in those fields outside of secondary education for which a master's degree has been approved, provided such a professional program is appropriate. For example, the M.Ed. degree may be earned with a major in English or geography. These programs require 6 credits in professional education approved in advance by the head of the department responsible for the minor field chosen, e.g., secondary education, agricultural education, etc.

Graduate Record Examination scores on both aptitude and education sections are required of all candidates.

SECONDARY EDUCATION (SEC ED)

400. Introduction to Research Literature (3)
426. Teaching Mathematics in the Secondary Schools (4)
433. Teaching Social Studies in the Secondary Schools (4)
436. Teaching of Conservation of Natural Resources in the Secondary School (3)
438. Teaching Science in the Secondary Schools (4)
443. Reading Problems in the Secondary School (2-3)
445. (E.E.C. 445, El.Ed. 445) Techniques in Remedial Reading (2-6)
451. Secondary Education in America (3)
453. Teaching English in the Secondary Schools (4)
454. Extracurricular Activities in the Junior and Senior High School (2-3)
472. Measurement of Achievement in the Secondary School (2-3)
497. Workshop in Selected Studies in Secondary Education (1-6)

510. Internship in Secondary School Teaching (3-6) Internship to take place in schools or educational situations where student is not regularly employed, under supervision of graduate faculty.

526. Research Problems in the Teaching of Mathematics (3) Research techniques and procedures dealing with the study of curriculum, materials, evaluation, teaching, learning, and supervision of mathematics. Prerequisites: Sec.Ed. 426, Ed.Psy. 406, and teaching experience.

532. Supervision of Student Teachers (3) A course in supervision for master teachers, department heads, and college teachers with supervisory responsibilities in teacher education. Prerequisites: teaching experience and 18 credits in education including at least 5 in methods.

533. Research Problems in the Teaching of Social Studies (3) Historical-philosophical bases for the social studies: curriculum development, research findings and techniques, learning resources and promising proposals. Prerequisites: Sec.Ed. 433 and teaching experience.

537. (Biol. 537) Workshop in the Biological Sciences (3) Projects designed for teachers of biology in the secondary schools.

538. Research Problems in Science Teaching (3) Problems and research dealing with curriculum, materials, evaluation, and supervision of science teaching and learning. Prerequisites: Sec.Ed. 438 and teaching experience.

539. Research Problems in the Teaching of English (3) Cooperative study by specialists, teachers, and administrators of problems and research findings in the teaching of English in American schools. Prerequisites: Sec.Ed. 453 and teaching experience.

546. (El.Ed. 546) Seminar on Reading Instruction (3-6) Research procedures and materials in reading readiness, word perception, basic reading skills, vocabulary development, reading in content subjects. Prerequisite: Sec.Ed. 443 or El.Ed. 443.

550. Problems in Modern Secondary Education (3) Historical, psychological, social, and economic factors influencing secondary education. Prerequisite: secondary school teaching.

551. Seminar in Contemporary Issues in the Secondary School Curriculum (2-3) Principles and philosophy of curriculum construction. Each student works out an individual problem in the secondary school curriculum. Prerequisites: 12 credits in education and psychology, and teaching experience.

553. Organization and Administration of the Junior High School (2-3) Problems in reorganization of secondary education, with particular reference to philosophy, organization, and teaching problems of the junior high school. Prerequisites: 12 credits in education and psychology, and teaching experience.

585. Curriculum Construction (2-3) Functions of administrators, supervisors, teachers, pupils, and laymen in curriculum building to meet pupil and community needs.

594. Seminar in Secondary Education (1-3) Conferences and discussions designed to meet the need for special study of particular fields in secondary education. Prerequisite: 12 credits of graduate work in education.

598. Problems, Projects, and Area Studies in Secondary Education (1-6) Independent work in the study of topics in secondary education or the development of new curriculums, materials, or procedures for teaching. Prerequisites: 12 credits of graduate work in education and approval of the department head.

SLAVIC LANGUAGES AND LITERATURES (S L L)

William R. Schmalstieg
Acting Head of the Department of Slavic Languages
127 Sackett Building

Degree Conferred: M.A.

Graduate Faculty, Senior Members: Professors Magner and Schmalstieg.
Graduate Faculty, Associate Member: Associate Professor Birkenmayer.

Opportunities for specialization in literature or linguistics are available. A minimum equirement for admission is an undergraduate major in Russian or its equivalent. The department prefers that M.A. candidates in this major submit a term paper ather than a thesis.

USSIAN (RUS)

26. Dostoevsky (3)
27. Tolstoy (3)
30. Methods and Materials for Teaching Russian (3)
50. History of the Russian Language (3)
60. Linguistic Analysis of Contemporary Russian (3)

1G. Technical Russian for Graduate Students (3) Prepares student to translate technical and scientific texts. No previous knowledge of Russian is required.

2G. Russian Texts (3) Development of skill in translating Russian texts in the sciences and social sciences. Prerequisite: Rus. 5 or 1G.

01. Readings in Russian Literature (3-6) Prerequisite: Rus. 204.

25. Pushkin (3) Pushkin's significance in Russian literature; his relation to other European literatures; *Eugene Onegin* and selected shorter works.

40. Seminar in Old Russian Literature (3) Literary and linguistic analysis of Russian literary monuments in the original, 1100-1800. Prerequisite: Rus. 450.

42. Seminar in Soviet Literature (3-6) Works of representative Soviet writers; individual research in contemporary Soviet literature and literary criticism.

70. Seminar in the Analysis of Old Russian Literary Documents (3-6) Reading, translation, interpretation, and analysis of old Russian literary documents. Texts differ from those read in Rus. 540. Prerequisite: Slav. 550.

LAVIC (SLAV)

00. Bibliography and Research Techniques (3) Tools and methods of research, designed for students preparing to do independent investigation of problems in Slavic languages and literature.

10. Structure of the South Slavic Languages (3-12; 3 credits per language) Linguistic analysis of a particular South Slavic language (Bulgarian, Macedonian, Serbo-Croatian, Slovenian). Comparative study of all the South Slavic languages. Prerequisite: Rus. 460 or one graduate course in linguistics.

50. Old Church Slavic (3) Reading and study of that corpus of religious and liturgical documents representing the first written records of a Slavic tongue.

60. Theory and Technique in Slavic Linguistics (3-6) Analysis of the relationship of the Slavic languages; consideration of particular linguistic problems within one or more of the languages.

* No graduate credit is given for this course.

SOCIAL STUDIES (SO ST)

HUGO A. MEIER
Chairman of the Committee on Social Studies
112 Sparks Building

Degree Conferred: M.Ed.

This program, designed to meet the needs of secondary school teachers, require at least 24 credits chosen from economics, history, human geography, political science and sociology. A candidate is expected to complete at least 3 credits each in four o these areas but not more than 12 in any one of them. A minor of at least 6 credit in educational foundations is also required.

For admission a student must have had solid preparation in the basic courses i economics, history, political science, and sociology and should have had some ad vanced undergraduate work in at least one of these areas. He must also have had 1 credits in education and related psychology, and he should be certified for teachin social studies. Ideally, he should have had teaching experience in this field as wel

SOCIOLOGY (SOC)

DONALD P. KENT, *Head of the Department*
237 Temporary Office Building

Degrees Conferred: Ph.D., M.A.

Graduate Faculty, Senior Members: Professors Buck, Clark, Kent, Mather, M. B. Mat son, Sherif, and Theodorson; Associate Professors Aurbach and Dansereau.

Graduate Faculty, Associate Members: Professor Foreman; Associate Professors Faulk ner, Raphael, and Sim; Assistant Professors Gardezi and Westby.

Major research and instructional areas of emphasis include sociological theory, re search methods and statistics, social psychology, demography and ecology, communit structure, industrial and occupational sociology, gerontology, and the sociologica analysis of institutions, including political, religious, and educational sociology.

Undergraduate preparation must include 12 credits in sociology and at least 6 i other social sciences. Students of exceptional ability who are deficient in under graduate preparation may be accepted provided they make up their course deficienc without graduate credit.

A thesis is required of all M.A. candidates in this major.

SOCIOLOGY (SOC)

400. ADVANCED GENERAL SOCIOLOGY (3)
401. SOCIAL INSTITUTIONS (3)
403. ADVANCED SOCIAL PSYCHOLOGY (3)
404. SMALL GROUPS (3)
406. SOCIOLOGICAL ANALYSIS OF DEVIANCE (3)
408. SOCIAL ECOLOGY (3)
412. PENOLOGY (3)
413. METHODS AND TECHNIQUES OF SOCIAL RESEARCH (3)

415. The Urban Community (3)
416. (C.F.Ed. 416) Sociology of Education (3)
418. The Development of Social Thought (3)
419. Negro-White Relations (3)
422. History of Sociological Theory (3)
423. Population Analysis (3)
424. Social Change (3)
426. Public Welfare Policy and Services (3)
427. Social Case Work (3)
428. Seminar in Sociology (1-6)
429. Social Stratification (3)
430. Family in Cross-Cultural Perspective (3)
432. Collective Behavior (3)
435. Social Gerontology (3)
436. (Journ. 436) Sociology of Opinion Formation (3)
438. (Rl.St. 438) Religion and Urban Society (3)
444. Complex Organizations (3)
446. Political Sociology (3)
450. Community Organization (3)
453. (Anthy. 453) Primitive Religion (3)
454. (L.M.R. 454) Industry and the Community (3)
455. (L.M.R. 455) Occupations and Professions (3)
456. Readings in Sociology (1-9)
457. (L.M.R. 457) Field Work in Industrial Sociology (1-6)
461. (Rl.St. 461) Sociology of Religion (3)
470. Intermediate Social Statistics (4)
473. Methods of Demographic Analysis (3-6)
499. Foreign Study in Sociology (2-6)

500. Seminar in Group Theory (1-3) The group as a unit of social structure and action.

502. Theories of Society (3) Past and present theories of the over-all structure and processes of societal functioning.

503. Research Seminar in Social Psychology (3-6) Design and conduct of research in areas of mutual interest in social psychology.

504-505. Current Social Theory (3 each) Current contributions to social theory; their relations to each other and to the larger theoretical structure.

506. Seminar in Sociological Theory (3-9)

507. Introduction to Graduate Study in Sociology (1) Required of all incoming graduate students in sociology.

510. Field Work in Sociology (1-6)

512. Seminar in Deviant Behavior (2-6) Advanced sociological study of crime, juvenile delinquency, mental disorders, suicide, drug addiction, prostitution, and other social deviation. Prerequisite: 6 credits in sociology.

513-514. Sociological Methods (3 each) Critical review of methodological issues; philosophy of science; research designs; analysis and interpretation of findings. Prerequisites: Soc. 413, 470.

515. Seminar in Community Studies (3)

518. Research Studies in the Sociology of Education (3) Analyses of the design, methods, and findings of selected classical and current research studies in the sociology of education. Prerequisite: Soc. 416.

523. Seminar in Population Theory (1-6) Critical review of population theory and research with emphasis on the sociological aspects of demographic behavior. Prerequisite: 3 credits in population or human ecology.

525. Seminar in Sociology (1-6) Research problems in theoretical and applied sociology.

529. Seminar in Intergroup Relations (3) Review of research into minority-majority group relations.

530. Research on Marriage and the Family (3) Training in methods and techniques of research in family relations. Experimental, statistical, and comparative studies are carried out, individually or cooperatively. Prerequisite: 3 credits of previous work in this field.

532-533-534. Social Relations (3 each) Critical appraisal of major social-psychological problems confronting modern man; emphasis on formulation of fruitful research projects and their evaluation. Prerequisite: 15 graduate credits in social science departments or psychology, including a course in statistics.

535. Seminar in Gerontology (2-6) A structural-functional analysis of current research dealing with the relationships between institutional structure, age grading and social behavior.

*546. Seminar in Political Sociology (3-6) Research and analysis of contemporary issues in political sociology. Prerequisite: 3 credits in statistics.

555. Industrial Sociology (3) Research methods and techniques in industrial sociology; current research, unexplored areas.

572-573. Social Statistics (3 each) Application of parametric and non-parametric statistical methods to sociology; sampling; computer data processing techniques. Prerequisites: Soc. 470 and 3 credits in research methods.

574-575. Quantitative Sociology (3 each) Problems and issues in the mathematical and quantitative aspects of sociology. Prerequisites: Soc. 413, 470.

SOLID STATE SCIENCE (S S S)

Laxman N. Mulay
In Charge of Graduate Programs in Solid State Science
101 Mineral Industries Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Brindley, Cross, Faust, Henisch, Kline, Muan, Mulay, Roy, and Walker; Associate Professors Barsch, Dachille, Inman, Newnham, Vastola, Vedam, Weber, and W. White; Mrs. Roy.

Graduate Faculty, Associate Members: Assistant Professors Johnson, Knox, McKinstry, and E. White.

This program is one of the options in which a graduate student in the Department of Materials Science can receive an advanced degree. The aim of this program is to

* 3 credits per term.

provide an opportunity for the student interested in the structure, properties, and behavior of solid materials to obtain an integrated program of courses encompassing both the necessary fundamentals of chemistry, physics, and mathematics and their technological and engineering applications.

The program of courses taken by a student majoring in this field must necessarily cut across two or more disciplines. The relevant subject matter has been grouped into four areas: (1) the structure of solids (crystal chemistry and structure determination); (2) theory related to the solid state (physics, chemistry, and mechanics); (3) properties of solids (optical, electrical, magnetic, mechanical, thermal, and chemical); and (4) reactions of solids (phase equilibria, reaction mechanisms, reaction kinetics, and surface reactions).

The course work of all students will normally include the "core program" as periodically redefined by the committee. Recommended course sequences for each year for students with different undergraduate backgrounds are prepared by the chairman and are available from the student's adviser.

Entering students should hold a bachelor's degree in chemistry, physics, mathematics, geological science, engineering, ceramics, or metallurgy, or in a closely related field that will have included in it mathematics at least through integral calculus and a minimum of one year of physics and one year of chemistry. They should be interested specifically in an interdisciplinary program of study and research. Dissertation research on various aspects of the solid state may be conducted in the Materials Science Department and other appropriate departments in the Colleges of Earth and Mineral Sciences, Engineering, and Science; in the Materials Research Laboratory; and in the Ordnance Research Laboratory. The experimental facilities for research in several aspects of materials science and engineering are exceptional.

S.S.S. 500 (seminar) and S.S.S. 590 (special research problems) will be offered to promote the interdisciplinary aspects of solid state science. Further information will be available from the S.S.S. office.

In addition to the departmental courses, students may select appropriate course work from any engineering or science department. The following list includes those which are most commonly taken to satisfy the requirements; descriptions may be found under the appropriate department headings. Structure of Solids: Chem. 516; Gchem. 512; Min. 463, 500; Mn.Sc. 421, 510, 513. Solid State Theory: Chem. 544, 545, 565, 566, 567; E.Mch. 507, 516, 531, 540; Metal. 514; Phys. 410, 412, 470, 512-513, 517, 561-562, 571. Physical Properties of Solids: Cer.Sc. 506, 507, 508; Chem. 455; E.Mch. 414, 506, 530, 533, 546; Metal. 516; Nuc.E. 509. Chemical Reactions in Solids: Cer.Sc. 503, 504, 511, 512; Chem. 563; F.Sc. 506, 515; Gchem. 513, 520; Metal. 508, 515, 518, 522.

SOLID STATE SCIENCE (S S S)

500. Seminar in Solid State Science (1 per term) Topics from current research depicting various aspects of the solid state.

590. Research Problems in Solid State Science (1-4) Specialized theoretical and/or experimental techniques related to research topics in solid state science.

SPANISH (SPAN)

Anthony M. Pasquariello
Head of the Department of Spanish, Italian, and Portuguese
212 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Moser, Pasquariello, Pérez, and Sturcken; Associate Professor Brentin.
Graduate Faculty, Associate Members: Associate Professors Dalbor and Triolo, Assistant Professors Halsey and Solera.

The minimum requirement for admission will normally be 24 credits of post-intermediate work in Spanish language and literature. A student may specialize in either the area of literature or descriptive and historical linguistics. The department may waive the requirement of a thesis for M.A. candidates in this major.

SPANISH (SPAN)

400. Advanced Composition and Conversation (3)
404. The Evolution of Spanish (3)
413. The Teaching of Spanish (4)
414. Spanish Phonology (3)
416. Old Spanish Literature (3)
426. The Golden Age (3)
427. Drama of the Golden Age (3)
439. Don Quijote (3)
*450. Spanish Institute (7-14)
452. Spanish Literature in the Romantic Period (3)
459. The Generation of 1898 (3)
472. The Contemporary Spanish-American Novel (3)
475. Introduction to Latin-American Literature (3)
476. Introduction to Latin-American Literature (3)
477. The Literature of Mexico (3)
480. Literature of the Gaucho (3)
482. Spanish Lyric Poetry (3)
483. Spanish Drama of the 19th Century (3)
487. The Spanish Novel of the 19th Century (3)
498. Problems in Hispanic Literature (3-12)
499. Foreign Study in Spanish (3)

502. Theory and Techniques of Teaching Spanish (1-3) Audio-lingual orientation.

503. Methods and Bibliography in Spanish (1-3) Methods of research; evaluation of sources and materials.

505. Old Spanish: Phonology, Morphology, and Syntax (3)

506. History of the Spanish Language (3)

507. Hispano-Romance Linguistics (3)

510. Spanish Descriptive Linguistics: Phonology (3)

511. Spanish Descriptive Linguistics: Morphology and Syntax (3)

514. Hispanic Dialectology (3) Early fragmentation among the peninsular dialects; origins and descriptive analysis of the American dialects; Judeo-Spanish.

515. Medieval Spanish Literature (3)

518. El Libro De Buen Amor (3)

* A maximum of 7 credits in one summer.

525. Spanish Renaissance and Golden Age Poetry (3) Lyric poetry, epic poetry, and balladry.

528. Spanish Renaissance and Golden Age Prose (3) Various types of novels with special emphasis on the picaresque; didactic literature; histories.

535. Seminar in Renaissance and Golden Age Literature (3-6) Nature and development of Spanish literature of the 16th and 17th centuries; topics will vary.

538. Theatre of Lope De Vega and His Cycle (3) Major works of Lope de Vega, Tirso de Molina, Guillén de Castro, Mira de Amescua, and others.

539. Theatre of Calderón De La Barca and His Cycle (3) Major works of Calderón de la Barca, Rojas Zorrilla, Augustin Moreto, and others.

540. Cervantes and His Works (3)

543. Spanish Literature of the 18th Century (3) Didactic literature, poetry, drama, and novel in the most representative writers in the century.

550. Spanish Realism (3) The major figures of the period with special emphasis on Pérez Galdós.

560. The Contemporary Novel in Spain (3) The novel since 1941: Cela, Laforet, Zunzunegui, Suárez Carreño, Matute, and others.

563. Contemporary Drama in Spain (3) The drama since 1898, to the present day: Benavente, Valle Inclán, García Lorca, Casona, Buero Vallejo, Sastre, and others.

564. Twentieth Century Hispanic Literature (3-6) Principal trends and works after the Generation of 1898 and *modernismo;* topics will vary.

570. Modernismo (3) The movement, its antecedents, and its followers, with special emphasis on Rubén Darío.

573. Survey of the Spanish-American Novel (3) Trends in the Spanish-American novel, such as *romanticismo, criollismo.*

575. The Spanish-American Essay (3) Tracing the history of ideas in Spanish America through major essayists.

576. Spanish-American Lyric Poetry (3) Aspects of Spanish-American lyric poetry, with emphasis on the 20th century after *modernismo.*

577. Spanish-American Drama (3) Dramatic literature in Spanish America from colonial times to the present.

578. Indianismo (3) The Indian as a theme in Spanish-American poetry and prose.

580. History of the Spanish Essay (3) The principal essayists from the 16th century to the present.

581. The Spanish-American Short Story (3) Critical analysis of the major writers and movements from Echeverría to the present.

585. Hispanic Poetry of the 19th and 20th Centuries (3) Various currents in the poetry of the Iberian peninsula and Latin America.

586. Evolution of the Picaresque Hero in Spanish Literature (3) An analysis of the changing character and his environment since Lazarillo to the present day.

598. Seminar in Hispanic Literature (3-12) Common and individual research in special problems in Spanish or Spanish-American literature.

SPEECH (SPCH)

STANLEY F. PAULSON, *Head of the Department*
305 Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.A., M.Ed.

Graduate Faculty, Senior Members: Professors Arnold, Brubaker, Holtzman, Nelson, Oliver, Paulson, Phillips, Schug, White, and Zelko; Associate Professor Fife.

Graduate Faculty, Associate Members: Associate Professors Borden, Dunham, Gregg, Hungerford, and Olbricht; Assistant Professor Grove.

The student may specialize in speech arts (interpretation, drama, theatre); radio and television; rhetoric and public address (including discussion, communication, teaching of speech); speech science (voice, diction, phonetics, general semantics); communicative theory; or international communication.

The minimum undergraduate preparation required is 12 credits in speech. Students who cannot meet this requirement in full may be admitted but must make up their deficiencies without credit toward the graduate degree. Spch. 400 and 502 are required of all graduate students who do not have their equivalents.

A thesis is required of all M.A. candidates in this major.

SPEECH (SPCH)

400. TEACHING OF SPEECH (3) *Mr. Schug*
402. GENERAL SEMANTICS (3) *Mr. Phillips*
410. ENGLISH PHONETICS AND PRONUNCIATION (3) *Mr. Brubaker*
412. SPEECH CRITICISM (3) *Mr. Arnold*
417. DIRECTING FORENSICS (3) *Mr. Dunham*
419. (Journ. 419) COMPARATIVE BROADCASTING SYSTEMS (3)
425. RADIO PROGRAMMING AND PERFORMANCE (3) *Mr. Nelson*
431. ANATOMY AND PHYSIOLOGY OF THE EAR AND VOCAL MECHANISMS (3) *Mr. Brubaker*
435. RADIO AND TELEVISION PROGRAMMING (3) *Mr. Nelson*
437. TELEVISION PROGRAMMING AND PERFORMANCE (3) *Mr. Hungerford*
450. DISCUSSION: RESEARCH AND THEORY (2-6) *Messrs. Grove and Phillips*
460. ORIENTAL RHETORIC (3) *Mr. Oliver*
461. CONTEMPORARY PUBLIC ADDRESS IN THE FAR EAST (3) *Mr. Oliver*
475. STUDIES IN MASS PERSUASION IN THE DEMOCRATIC SOCIETY (3) *Mr. Hager*
477. CONTEMPORARY PUBLIC ADDRESS: THE GREAT DICTATORS (2) *Mr. Oliver*
478. CONTEMPORARY PUBLIC ADDRESS: ENGLISH AND AMERICAN SPEAKERS (2) *Mr. Gregg*
485. ADVANCED ORAL INTERPRETATION OF LITERATURE (3) *Messrs. Hamilton and Wigley*
490. PSYCHOLOGY OF SPEAKING AND LISTENING (3) *Mr. Holtzman*
494. TEACHING OF ENGLISH AS A SECOND LANGUAGE (3) *Mr. Holtzman*
496. SPEECH FOR TEACHERS (3) *Mr. Butt*
498. DIRECTED STUDY (1-6) *Staff*

500. SEMINAR IN AMERICAN ORATORY (2-6) History of American oratory with application of critical standards to the work of specific orators. *Mr. White*

502. RESEARCH METHODS IN SPEECH (3) Research design, thesis proposals, and background for research in graduate study. Prerequisite: 6 credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Messrs. Dunham and Paulson*

505. Historical Development of Speech Theory and Criticism (2-4) Classical theories of speech-making from the earliest beginnings to the fall of the Roman Empire. *Mr. Arnold*

506. Historical Development of Speech Theory and Criticism (2-4) Theories of speech-making from the Renaissance to the present. *Mr. Arnold*

508. Seminar in British Oratory (2-4) History of British oratory; application of critical standards to the work of selected orators. *Miss Fife*

509. Problems in Rhetoric and Oratory (2-6) Comparative study of selected orators and rhetoricians. Prerequisite: 6 credits in speech. *Mr. Gregg et al.*

510. Problems in Speech Education (2-4) Advanced knowledge, theories, and principles, together with their philosophical, scientific, clinical, artistic, and educational implications for the teacher of speech. Prerequisite: Spch. 502 and 9 additional credits at the 400 or 500 level in speech, clinical speech, or theatre arts. *Mr. Phillips*

520. Seminar in Speech Science (2-4) Seminar in physical and physiological bases of speech and voice; introduction to laboratory techniques used in speech research. Prerequisite: 9 credits in speech, speech pathology and audiology, or psychology. *Mr. Brubaker*

540. Seminar in Problems of Television and Radio (2-4) Study and research in television and radio as they pertain to programming, production, relation to society, and speech. *Mr. Nelson*

550. Seminar in Oral Persuasion (2-4) Theory and devices of persuasion; analysis of persuasive discourse. Prerequisite: 6 credits in speech including Spch. 200. *Messrs. Holtzman and Paulson*

552. Oral Communication in Industry, Business, and Government (2-4) Needs, practices, and methods in American industry, business, and government; methods of training adults in oral communications skills. *Mr. Zelko*

554. Seminar in Small Group Communication (2-4) Communication variables in small groups. Experimental research and innovations in communication in vocational, therapeutic, and educational groups.

555. Speech Communication: Problems and Principles (2-6) Prevalent theories of speech influence. *Messrs. Borden and Phillips*

564. Seminar in European Oratory (2-4) Analysis of significant European speeches with consideration of cultural influences on invention and style. Prerequisite: 6 credits in speech. *Mr. Olbricht*

575. Research Problems in Speech (1-9) Advanced research on an individual basis in oratorical criticism, discussion techniques, persuasion, pedagogy, phonetics, speech science, and speech pathology. Prerequisite: 12 credits in speech or speech pathology and audiology.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

Bruce M. Siegenthaler
In Charge of Graduate Programs in Speech Pathology and Audiology
Speech and Hearing Clinic, Sparks Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Members: Professors McDonald and Siegenthaler, Associate Professor Frick.

Graduate Faculty, Associate Members: Associate Professors Berlin and Haspiel.

Students may specialize in speech pathology, audiology, or deaf education. Admission to study for the master's degree requires 27 credits in clinical speech and hearing, education, and psychology, including at least 9 in speech pathology and/or audiology and a course in statistics. The major is one of the areas of study within the Department of Special Education.

The degree programs include the requirement of a number of field trips to diagnostic and treatment facilities, and may include a period of internship at an off-campus location. Students should expect to have moderate expenses related to these trips.

SPEECH PATHOLOGY AND AUDIOLOGY (S P A)

430. Introduction to Audiology (3)
433. Methods in Auditory Training and Speech Reading (3)
434. Pure Tone Audiometry (3)
439. Practicum in Auditory Training and Speech Reading (1-5)
440. (E.E.C. 440) Survey of Speech and Hearing Disorders (3)
441. Current Problems in Speech Pathology and Audiology (1-6)
442. Speech Pathology: Articulation and Stuttering (3)
444. Speech Pathology: Voice and Organic Disorders (3)
445. Professional Programs and Relationships (3)
449. Practicum in Speech Therapy (1-6)
460-461. Teaching Speech to the Deaf (2 each)
462-463. Teaching Language to the Deaf (3 each)
464-465. Teaching Elementary School Subjects to the Deaf (2 each)
466. Problems in Education and Guidance of the Deaf (3)
469. Student Teaching with the Deaf (3-12)

530. Seminar in Audiology (1-6) Review of theories of hearing and review of related physiological and psychological researches. Prerequisite: S.P.A. 434.

531. Speech Audiometry and Hearing Aids (3) Techniques and interpretation of speech reception tests; hearing aids and hearing aid advisement procedures; observations and practice in test administration. Prerequisite: S.P.A. 434.

532. Acoustical Instruments for Hearing (3) Acoustical instrumentation used for research in hearing, programs of hearing conservation, and noise control, including clinical and industrial applications. Prerequisite: 6 credits in acoustics, audiology, experimental psychology, or speech science at 400 level.

538. Practicum in Audiologic Evaluation and Selection of Hearing Aids (1-5) Prerequisite: S.P.A. 531.

540. Articulation Disabilities (3) Speech-sound production disorders in children and adults; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

541. The Voice and Its Disorders (3) Physical, physiological, and psychological bases of voice production; causes, nature, and symptoms of its disorders; current clinical methods in voice improvement. Prerequisites: S.P.A. 444, 449.

542. Stuttering (3) Modern theories of causes of disorders of rhythm; methods of examination, diagnosis, and treatment. Prerequisites: S.P.A. 442, 449.

543. Diagnostic Procedures in Clinical Speech (3) Clinical instrumentation; case history taking; examination procedures and materials used in diagnosing speech disabilities; interpretation of findings; report preparation. Prerequisite: S.P.A. 444.

544. Cleft Palate (3) Anatomy, physiology, embryology, and growth of the palate and contiguous structures; etiology, diagnosis, habilitation of cleft palate problems. Prerequisite: S.P.A. 444.

545. (E.E.C. 545) Cerebral Palsy (3) Etiology and symptomatology of cerebral palsies; diagnosis and treatment of communication problems; the multi-professional habilitative program. Prerequisite: S.P.A. 444.

546. (E.E.C. 546) Aphasia and Allied Disorders (3) Aphasia and related disorders in adults and children: etiology, diagnosis, and treatment. Prerequisite: S.P.A. 444.

548. Practicum in Speech Diagnosis (1-3) Supervised practice in interviewing, counseling, speech evaluation, and synthesis of psychological medical and audiological data in speech diagnosis; report writing. Prerequisites: S.P.A. 444, 449.

549. Advanced Practicum in Speech Therapy (1-6) Theoretical and clinical rationale of therapy; professional role and relationships; therapy procedures, individual and group; evaluation of process and outcomes. Prerequisites: S.P.A. 442, 449.

550. Seminar in Speech Pathology (1-6) Advanced study of special problems and new developments in speech pathology. Prerequisites: S.P.A. 442, 444.

STATISTICS (STAT)

James B. Bartoo, *Head of the Department*
333 McAllister Building

Degrees Conferred: Ph.D., M.A., M.S.

Graduate Faculty, Senior Members: Professor Patil, Associate Professor Harkness.
Graduate Faculty, Associate Members: Professor Bartoo, Associate Professor Hultquist.

The modern science of mathematical statistics is concerned with the general principles of dealing with uncertainty and partial ignorance. Of fundamental importance to the discipline is the theory of probability, which is the study of mathematical models of random phenomena. Basic courses in statistics and probability are offered regularly.

To be admitted as a candidate for an M.A. or M.S. degree, an applicant must

possess an undergraduate degree with a solid background in mathematics. Additional training in probability and/or statistics is desirable but not necessary.

For the M.A. degree, the candidate must complete 30 course credits, with at least 18 credits (15 in statistics) of 500-series courses, Math. 421, and Math. 441 or 481 in addition to a term paper. For the M.S. degree, 12 credits of 500-series statistics courses, 6-9 credits of thesis, Math. 421, and Math. 441 or 481 are required.

Ph.D. candidacy is contingent upon passing three written qualifying examinations and a reading examination in French, German, or Russian. Completion of a second of these languages or a demonstration of proficiency in computer science is necessary before the comprehensive examination (taken after approximately 60 credits) is given.

STATISTICS (STAT)

400. Intermediate Statistical Analysis (3)
401. Statistical Methods (3)
402. Statistical Methods (3)
403. Statistical Methods (3)
409-410. (Math. 409-410) Introduction to Mathematical Statistics (3 each)
411. Practicum (1)
418. (A.M. 418, Math. 418) Discrete Probability Theory (3)

501. Theory of Statistics (3) Sufficiency and completeness, testing hypotheses, sequential analysis, chi-square tests, analysis of variance. Prerequisite: Stat. 410.

502-503. Analysis of Variance and Regression (3 each) Linear hypotheses, regression, analysis of variance and covariance, mixed and random effects models, multiple comparisons, designs. Prerequisites: Stat. 410; Math. 441 or 481.

504. Nonparametric Statistics (3) Goodness-of-fit tests, contingency tables, analysis of multinomial and percentage data, multi-sample problems, special topics. Prerequisite: Stat. 410.

505. Multivariate Statistical Analysis (3) Statistical procedures associated with the multivariate normal distribution. Prerequisites: Stat. 410; Math. 441 or 481.

506. Sampling Theory (3) Theory and application of sampling from finite populations. Prerequisite: 6 credits in statistics.

507. Sequential Analysis (3) A thorough discussion of sequential procedures of estimation and testing of hypotheses. Prerequisite: Stat. 554.

508. Characterization of Statistical Models (3) Characteristics of different statistical distributions; characterizations of distributions through structural properties and statistical procedures. Prerequisites: Stat. 518, 543.

509. Discrete Statistical Models and Methods (3) Systematic study of probability models and statistical methods pertaining to statistical analysis of data consisting of single and multiple counts. Prerequisite: Stat. 554.

512-513. (A.M. 512-513) Introduction to Stochastic Processes (3 each) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes. Prerequisite: Stat. 418.

517-518. (Math. 517-518) Probability Theory (3 each) Measure theoretic foundation of probability, distribution functions and laws, types of convergence, central limit problem, conditional probability, special topics. Prerequisites: Math. 452, 501.

542-543. (Math. 542-543) Statistical Distribution Theory (3 each) Random variables and expectations; discrete, continuous, univariate, multivariate, exact, and asymptotic distribution theory. Prerequisites: Math. 421 and 441 or 481.

553. Statistical Estimation and Testing I (3) Point estimation of one parameter; sufficiency; completeness; maximum likelihood; interval estimation. Prerequisite: Stat. 543.

554. Statistical Estimation and Testing II (3) Neyman-Pearson theory and lemma; uniformly most powerful tests; unbiased tests; large sample procedures. Prerequisite: Stat. 553.

558-559. (Math. 558-559) Theory of Stochastic Processes (3 each) Stationary, independent, and orthogonal processes, discrete and continuous Markov processes, martingales and semi-martingales applications. Prerequisite: Stat. 518.

561. Statistical Inference I (3) Multiparameter estimation; linear estimation; maximum likelihood estimation; Bayesian estimation; large sample properties and procedures. Prerequisite: Stat. 554.

562. Statistical Inference II (3) Testing statistical composite hypotheses; invariance principles; Bayesian statistics; large sample properties and procedures. Prerequisite: Stat. 561.

572. Statistical Decision Theory I (3) Structure of statistical games; optimal strategies, fixed sample-size games. Prerequisites: Math. 502, Stat. 561.

573. Statistical Decision Theory II (3) Sufficient statistics; the invariance principle; estimation and testing. Prerequisite: Stat. 572.

577. (Math. 577) Special Topics in Probability (3-12) Special topics in probability which are not offered regularly but which are of special interest to faculty and students.

590. Seminar in Statistical Methods (1-6) Lectures on current statistical methods; presentation and discussion of literature treating various special topics in statistics.

591. (Math. 591) Seminar in Probability Theory (1-6) Lectures on current and recent research in various special topics in probability theory.

592. Special Topics in Statistics (3-12) Special topics in statistics which are not offered regularly but which are of special interest to faculty and students.

*THEATRE ARTS (THEA)

William H. Allison, *Head of the Department*
103 Arts Building

Degrees Conferred: M.A., M.F.A.

Graduate Faculty, Senior Members: Professors Smith and Walters; Associate Professors Manfull, Reifsneider, and Yeaton.
Graduate Faculty, Associate Member: Associate Professor Allison.

The M.A. program is planned to provide breadth of studies in theatre. A thesis in some area of specialization is required.
The M.F.A. program is planned to provide a professional emphasis. Students will take a core program and specialize in performance (acting, directing), dramatic

* Courses have been changed; students should consult the department.

writing, or production (scene design, technical direction, stage lighting, stage costuming).

Under certain circumstances the Ph.D. degree is offered by the Department of English with specialization in drama and minor work in theatre arts.

Requirements for admission to the M.A. program are a broad undergraduate preparation; one course each in basic acting, directing, theatre crafts, and history of the theatre, or their equivalents; and 12 credits divided among speech, music, art, and dramatic literature, or 9 credits in one of these fields.

Requirements for admission to the M.F.A. program are:

1. Twenty-four credits in theatre arts, 3 of which must be in history of the theatre. In certain cases courses in speech, dramatic literature, art, music, dance, architecture, and other similar subjects may be accepted. Substantial theatre experience may be accepted in appropriate substitution for entrance credits at the discretion of the department.

2. Auditions or submission of manuscripts, portfolios, photographs of theatre work, or other evidence of ability, according to specialization, as arranged by the student with the department.

All students in the M.A. and M.F.A. programs who lack the expected upper-class undergraduate courses in theatre may be requested to take additional course work without degree credit. All graduate majors are required to participate in University Theatre productions in positions of responsibility.

THEATRE ARTS (THEA)

404. Styles of Acting (3-6)
412. Advanced Scene Design (3-6)
413. Stage Lighting (3)
414. Stage Costuming (3)
415. Theatre Organization and Management (3)
421. Advanced Playwriting (3)
430. Ancient and Medieval Theatre (3)
431. Theatres of the Renaissance and the Orient (3)
432. History of the Modern Theatre (3)
433. Dance for the Theatre (3)
442. Creative Dramatics with Children (3)
443. Marionettes and Puppetry (3)
451. Directing (3-6)
452. Central Staging (3)
470. Theatre Production (1-6)
471. The European Film (3)
472. The American Film (3)
473. Motion Picture Techniques (3-6)
481. Television Drama (3)
482. Radio and Television Directing (3)

501. Directing (1-6 per term)

502. Technical Theory in Dramatic Production (3-6)

504. Styles of Acting (3-12)

506. The Contemporary Theatre (3-6)

507. Dramatic Theory (3-6)

512. Stage Design (1-6 per term)

521. Playwriting (3-12) Prerequisite: Thea. 421.

VOCATIONAL INDUSTRIAL EDUCATION (VI ED)

JOSEPH T. IMPELLITTERI
Chairman of Graduate Education and Research
Department of Vocational Education
248 Chambers Building

Degrees Conferred: Ph.D., D.Ed., M.S., M.Ed.

Graduate Faculty, Senior Member: Professor Brandon.

Graduate Faculty, Associate Members: Professor Williams, Associate Professors Brantner and Impellitteri.

Emphasis may be placed upon preparation for teaching, supervision, administration, or teacher education. Graduation from an approved major in industrial education is required for admission.

INDUSTRIAL EDUCATION (I ED)

402v. SUPERVISION OF VOCATIONAL EDUCATION (3)
403v. SUPERVISED FIELD WORK (6)
408v. OCCUPATIONS (3)
409v. TESTS AND MEASUREMENTS (3)
412v. SPECIAL PROBLEMS IN VOCATIONAL EDUCATION (4)
415v. PROBLEMS IN COORDINATING VOCATIONAL EDUCATION (3)
420v. OCCUPATIONAL HYGIENE (3)
427v. ADVANCED COURSE OF STUDY BUILDING (3)
446v. IMPROVEMENT OF INSTRUCTION IN VOCATIONAL EDUCATION (4)
450v. SHOP LAYOUT AND MANAGEMENT (3)

501v. SEMINAR IN VOCATIONAL EDUCATION (6) Conferences, investigations, and discussion for advanced students and mature persons who have had experience as teachers, supervisors, or administrators.

506v. ADMINISTRATION OF VOCATIONAL EDUCATION (3) The job of the local director of industrial education in organizing and developing city and other local programs of industrial education. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

510v. VOCATIONAL EDUCATION FOR ADMINISTRATORS (3) Designed for school administrators and supervisors who desire an understanding of practical arts and vocational education. Prerequisite: I.Ed. 1v or trade or teaching experience.

550v. RESEARCH IN VOCATIONAL EDUCATION (3) Research techniques in vocational industrial education.

556v. FEDERAL LEGISLATION (2-3) Recent federal legislative activities and executive orders that bear directly and indirectly upon industrial education.

557v. PRESENT-DAY LOCAL, PERSONNEL, AND CURRICULUM PROBLEMS (2-3) Various plans, techniques, and practices.

558v. STATE AND LOCAL SUPERVISION AND ADMINISTRATION (2-3) The more important recent problems in organization, supervision, and administration.

559v. VOCATIONAL TECHNICAL EDUCATION (2-3) Problems of organization and administration of programs of technical education at the secondary and post-

secondary levels. Prerequisite: 6 credits in industrial education, valid director's certificate, or equivalent training and experience.

560v. Philosophy of Industrial Education (3) Principles and beliefs of progressive industrial education; literature for evaluating instructional practices. Prerequisite: 12 credits in industrial education or teaching experience.

WILDLIFE MANAGEMENT (W L M)

Wilber W. Ward, *Director of the School of Forest Resources*
101 Ferguson Building
or
Tien-Hsi Cheng, *Professor of Zoology*
208 Life Sciences Building

Degree Conferred: M.S.

Graduate programs in the field of wildlife management are offered by the Department of Forestry and Wildlife for students primarily interested in the habitat aspects, and by the Department of Biology for those primarily interested in the animal aspects.

ZOOLOGY (ZOOL)

Tien-Hsi Cheng
In Charge of Graduate Programs in Zoology
208 Life Sciences Building

Degrees Conferred: Ph.D., M.S.

Graduate Faculty, Senior Members: Professors Anderson, Anthony, Cheng, Cooper, Dalton, and Hale; Associate Professors Bellis, Houlihan, Hymer, and Lytle.

Graduate Faculty, Associate Members: Associate Professors Butler, Wickersham, and Wood; Assistant Professor Dunson.

Zoological programs are offered in animal behavior, cell biology, developmental biology, ecology, endocrinology, fishery biology, genetics, histology, ichthyology, invertebrate zoology, morphology, physiology, population dynamics, or wildlife management. The bachelor's program must show emphasis on zoological subjects and include adequate preparation in mathematics and physical sciences. Each applicant must provide Graduate Record Examination scores, letters from two persons most familiar with his academic qualifications, and a personal statement of his primary interests and objectives. A limited deficiency may be made up without degree credit while pursuing graduate work.

See also Genetics and Physiology

BIOLOGY (BIOL)

401. (Pty.Sc. 401, Psy. 401) Animal Behavior (3)
403. (Ent. 403) Systematics (3)

408. Mammalogy (4)
410. General Limnology (3)
415. The Literature of Zoology (1)
416. The Methods of Research in Zoology (2)
417. Invertebrate Zoology (3)
419. General Animal Ecology (3)
421. Comparative Anatomy of Vertebrates (4)
430. (Bphys. 430) Molecular Biology of the Gene (3)
437. Histology (4)
440. Embryology (4)
444. Zoological Problems (1-6)
448. Ornithology (3)
452. Ichthyology (3)
461. Animal Parisitology (3)
471. Vertebrate Physiology (3)
475. Cell Physiology (3)
479. General Endocrinology (3)
480. Marine Biology (3)

501. Evolution (2) Selected topics on the evolution of life.

509. Techniques in Wildlife Management (2) Evaluation of procedures designed to manage populations of game and fish; elements of statistics of birth and mortality rates; census methods. Fall term.

513. Biology Seminar (1 per term) Presentation and discussion of selected topics.

538. Principles of Microscopic Histochemistry (2) Theoretical basis for the microscopic identification, localization, and quantitative analysis of chemical substances in tissues of organisms. Prerequisite: Biol. 405 or 437.

539. Analytical Histochemistry Laboratory (2-4) Application of histochemical techniques in the microscopic analysis of tissue lipids, proteins, carbohydrates, nucleic acids and proteins. Prerequisite or concurrent: Biol. 538.

541. Comparative Physiology (3) Phylogenetic variation in the regulation of the internal environment of animals.

546. Principles of Animal Populations (3) Ecological laws governing population growth and decline; reproductive and mortality rates; predation and composition as limiting factors. Fall term.

551. Fisheries Management (3) Basic principles underlying management of inland waters for fish production.

571. (Phsio. 571) Animal Physiology (2) Physiology of fluid transport mechanisms; examination of the distribution and regulation of body fluids, blood, and hemodynamics. Prerequisite: 3 credits in physiology.

572. (Phsio. 572) Animal Physiology (2) Examination of nutrition, metabolism, and respiration as they relate to subcellular, cellular, and organ organizational levels of the whole animal. Prerequisite: 3 credits in physiology.

573. (Phsio. 573) Animal Physiology (2) Detailed examination of animal reproduction, endocrine secretion and control, neural muscular activity, central nervous system correlates, and special senses. Prerequisite: 3 credits in physiology.

574. (Phsio. 574) Animal Physiology Laboratory (3) Selected problems using advanced physiological techniques to study transport mechanisms, circulation, excretion, respiration, metabolism, and neuroendocrines. Prerequisites: Phsio. 571, 572. Prerequisite or concurrent: Phsio. 573.

575. Advanced Cell Physiology (3) Current topics and experiments in cell physiology.

581. Advanced Invertebrate Zoology (3) Morphology, physiology, taxonomy, and life histories of invertebrate animals.

582. (Pty.Sc. 582, Psy. 582) Research in Animal Behavior (2-6 per term) Research in special areas of animal behavior involving field or laboratory work.

583. Experimental Endocrinology (4) Problems in endocrinology designed to demonstrate the role of hormones in the regulation of physiological phenomena.

Note: *See Botany for additional courses.*

OTHER ELECTIVE GRADUATE COURSES

The following courses are in fields in which neither major nor minor work is offered at this institution. The courses, however, carry graduate credit and, with the approval of the major department, may be applied toward the requirements for a degree either as elective courses or as a part of a general studies program. The usual restrictions upon the use of 400 series courses in degree programs apply to these courses.

AGRICULTURE, GENERAL (AG)

400. Introductory Biometry (3) *Mr. Bennett*

AMERICAN STUDIES (AM ST)

402. Seminar in American Studies (3-9)

ANIMAL SCIENCE (AN SC)

422. Quantitative Inheritance and Animal Breeding (3) *Mr. Hicks*

APPLIED MATHEMATICS (A M)

405. (Math. 405) Fourier Series and Partial Differential Equations (3)
417. (Math. 417) Tensor Analysis (3)
418. (Math. 418, Stat. 418) Discrete Probability Theory (3)
419. (Phys. 419) Theoretical Mechanics (3)
431. (Math. 431) Ordinary Differential Equations (3)
441. (Math. 441) Matrix Algebra (3)
451. Functions of Several Variables (3)
452. (Math. 452) Functions of a Complex Variable (3)
461. (Phys. 461) Theoretical Mechanics (3)
490. Special Topics (1-12)

510-511. Linear Methods (3 each) Matrices, quadratic forms, ordinary and partial differential equations, integral equations, transforms, Fourier series. Prerequisite or concurrent: A.M. 452.

512-513. (Stat. 512-513) Introduction to Stochastic Processes (3) Markov chains, random walk and recurrent events, queuing theory, time-dependent stochastic processes.

520. Asymptotic Techniques in Differential Equations (3) Asymptotic series; applications to ordinary and singular perturbation problems. Prerequisite: A.M. 511.

540. Magnetohydrodynamics (3) The mathematical description of the interaction of an electrically conducting fluid with electromagnetic fields. Prerequisites: A.M. 511, Phys. 557.

550. (Phys. 550) Applied Group Theory (3) Representations of discrete and continuous groups, applications to theoretical physics and differential equations, varying emphasis on the specific applications. Prerequisite: A.M. 510.

555. Introduction to Group Representations (3) An introduction to matrices, groups, group representations, characters, and orthogonal functions, with orientation to chemistry and physics.

590. Special Topics (2-12) Various topics according to instructor and students. Prerequisite: second-year graduate standing.

THE ARTS (ARTS)

400. Contemporary Forms in Art, Music, Theatre (3)

CONSUMER STUDIES (C S)

420. Consumer Industries (4)
430. Societal Aspects of Consumer Problems (2)

CULTURAL FOUNDATIONS OF EDUCATION (CF ED)

416. (Soc. 416) Sociology of Education (3)
417. Philosophic Basis of Education (3)
418. History of Education in the United States (2-3)
419. History of Education in Ancient and Medieval Times (3)
420. History of Modern European Education (3)
422. Introduction to Comparative Education (3)

515. Experimentalist Philosophies of Education (2-3) John Dewey's educational philosophy and later formulations by Bode, Kilpatrick, Childs, Brameld, and others. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

516. Topical Seminar on School and Society (2-6) An intensive and comprehensive analysis of one selected aspect of the relationship of educational institutions to their societal setting. Prerequisite: C.F.Ed. 416.

519. Contemporary Philosophies of Education (2-3) Implications for education of various types of Realism, Idealism, Existentialism, and Analytic philosophy. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

520. Comparative Philosophies of Education (2-3) Effect of ideologies on education in selected national systems; emphasis on relationships between theory and educational practice. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

521. Education in the Latin-American Countries (2-3) Recent educational progress in Central and South America, with special reference to Mexico, Cuba, Puerto Rico, Brazil, Chile, and Argentina. Prerequisite: C.F.Ed. 422 or 6 credits in Latin-American studies.

522. Comparative European Education (2-3) Educational policies and practices in school systems in western and central European nations. Prerequisite: C.F.Ed. 422.

524. Education in Communist Countries (2-3) Educational policies and practices in Soviet Russia and other Communist countries. Prerequisite: C.F.Ed. 422 or 6 credits in Russian or Asian studies.

526. Education in Developing Countries (2-3) Educational problems and trends in selected countries, with particular reference to Africa, the Middle East, and Southeast Asia. Prerequisite: C.F.Ed. 422 or 6 credits in Asian, African, or Latin-American studies.

528. Education in Canada (2-3) Development and organization of education in the Canadian provinces; emphasis on dual systems of Ontario and Quebec. Prerequisite: C.F.Ed. 422.

532. Social Change, Cultural Dynamics, and Education (2-3) The social role of the school in a rapidly changing society. Prerequisite: C.F.Ed. 416.

534. Readings in Philosophy of Education (1-6) Selected philosophic writings—classic, modern, or contemporary—on education. Prerequisite: C.F.Ed. 417 or 6 credits in philosophy.

536. Educational Leaders and Classics (2-3) Selected leaders and their writings, with emphasis on historical-social context, including Quintilian, Erasmus, Comenius, Feelon, Pestalozzi, and Mann.

592. Seminar in Cultural Foundations of Education (1-9) Conferences and discussions designed to meet the need for special study of particular areas in cultural foundations of education. Prerequisites: 12 credits of graduate work in cultural foundations of education.

ENGINEERING (ENGR)

450. Patent Fundamentals (3)

500. Special Topics in Engineering (1-3)

531. Advanced Digital Computer Programming (3) Nonnumerical applications; symbol manipulation, syntactical analysis, and translation of artificial languages; heuristic methods, learning mechanisms, artificial intelligence.

ENGINEERING GRAPHICS (E G)

421. Engineering Graphics for Teachers (3)

HEALTH PLANNING AND ADMINISTRATION (H P A)

401. Introduction to Medical Care Organization (3)
410. Principles of Public Health Administration (3)
430. Principles of Health Planning (3)
431. Health Planning Methods (3)
432. Health Services Evaluation (3)

HUMAN DEVELOPMENT (H DEV)

401. Professional Issues in Human Development (1-3)
499. Senior Thesis (1-10)

INSTRUCTIONAL MEDIA (INST M)

435. Orientation to Instructional Media (2)
436. Production and Utilization of Graphic Stimulus Materials (3)
437. Production of Educational Motion Pictures (3)
443. Television in Education (3)

531. Organization and Administration of Media in Schools (2) Problems of providing instructional media in schools; the role of the media consultant in curriculum construction. Prerequisite: Inst.M. 435.

INTERNATIONAL UNDERSTANDING (INT U)

400. World Affairs and International Understanding (3-6)

ITALIAN (IT)

598. Seminar in Italian Literature (3-12) Common and individual research in special problems.

LABOR-MANAGEMENT RELATIONS (L M R)

400. Comparative Industrial Relations Systems (3)
411. Trade Union Administration (3)
414. (Econ. 414) Theories of the Labor Movement (3)
415. Labor Movements in Developing Areas (3)
421. Labor Education (3)
433. (Pl.Sc. 433) The Law of Labor-Management Relations (3)
454. (Soc. 454) Industry and the Community (3)
455. (Soc. 455) Occupations and Professions (3)
456. (Hist. 456) History of American Labor (3)
457. (Soc. 457) Field Work in Industrial Society (1-6)
498. Problems in Labor Studies (1-9)

LANDSCAPE ARCHITECTURE (L ARCH)

420. Landscape Ecology (3)
425-426. Landscape Construction Problems (3 each)
427. Landscape Construction Problems (2)
434. Urban Park and Recreation Areas (3)
454-455. Landscape Design (3 each)
460-461-462. Advanced Landscape Design (4-8 each)
471. Park Systems (2)
472. Planning and Public Policy (3)
473. Recreation Resource Planning (3)
474. Site Engineering Fundamentals (1)

518. Advanced Problems in Landscape Design (2-12) Selected problems for original investigation in the design, construction, and maintenance of landscape architectural projects.

521. Technical Landscape Architectural Practices (2-12) Specific technical and professional problems in landscape architectural planning and practice. Prerequisites: L.Arch. 462, 471.

LIBERAL ARTS (L A)

498. Undergraduate Seminar: Selected Topics (3-9)

LINGUISTICS (LING)

400. Introduction to Transformation Grammar (3)
402. Historical Linguistics (3)

500. Generative Linguistics (3) Types of grammatical rules and their interrelations; algorithm for assigning structural descriptions; evaluation procedure for selecting best compatible grammar.

501. Psycholinguistics (3) The relationship between the behavioral, probabilistic view and the structuralist, deterministic view of language as a system of habits.

503. Generative Syntax (3) Grammatical rules specifying well-formed strings; conditions on analyzability and assigning of structural descriptions; deviation from well-formedness. Prerequisite: Ling. 400.

504. Generative Phonology (3) Distinctive feature theory in the generative framework; articulatory and acoustic correlates; nonphonemic features. Prerequisite: Ling. 400.

505. Seminar in Historical Linguistics (3) Detailed study of some problem of historical linguistics, e.g., the laryngeal theory, Indo-European ablaut, etc. Prerequisite: one course in historical linguistics.

LITHUANIAN (LITH)

500. Structure of Lithuanian (3) Analysis of the phonology, morphology, and syntax of Lithuanian; comparative linguistic study of Balto-Slavic and Indo-European. Prerequisite: 1 graduate course in linguistics.

MINERAL SCIENCES (MN SC)

411. Instrument Techniques Applied to Mineral Science Problems (1-4)
Unit A. X-ray Diffraction
Unit B. Electron Microscopy
Unit C. Spectroscopy
Unit D. Electron Probe Analysis
421. X-ray Diffraction (3)
431. Instrumentation for Physical Measurement and Control (3)

510. X-ray and Electron Diffraction Analysis as Applied to Minerals and Metals (2-4) Prerequisite: Mn.Sc. 421.

513. Semiconductor Physics (3) Electronic structure of solids; electronic transport phenomena; semiconductor materials; luminescence. Prerequisite: Phys. 400 or E.E. 32. *Mr. Henisch*

530. Electron Transmission Microscopy in the Materials and Mineral Sciences (3) Discussion of electron image contrast theory as a tool for study of atomic substructures in the materials and mineral sciences.

POLISH (POL)

501. Readings in Polish Literature (3-6) Individual reading and research in nineteenth and twentieth century Polish literature and literary criticism.

PORTUGUESE (PORT)

598. Seminar in Portuguese and Brazilian Literature (3-12) Common and individual research in special problems.

RELIGIOUS STUDIES (RL ST)

402. Contemporary Religious Thought (3)
408. Hinduism (3)
409. Buddhism (3)
421. Culture and Religious Reform (3)
430. Religion and Morality (3)
438. (Soc. 438) Religion and Urban Society (3)

440. Problems in Religious Studies (3-6)
461. (Soc. 461) Sociology of Religion (3)

502. Studies in Comparative Religions (3-6) Cross-cultural comparative studies of two or more major world religions.

505. Seminar in Asian Religions (3-6) Studies in selected Asian religions.

520. Early and Medieval Western Religion (3-6) Studies in Judaism and Christianity from the 1st century A.D. to 1500.

530. Religion and Society (3-9) Studies of mutual influences and effects of religious and secular phenomena.

VETERINARY SCIENCE (V SC)

401. Ecology of Animal Disease (3)
420. General Animal Pathology (3)

515. (Micrb. 515) Virology (2-4) Rickettsial and viral agents parasitizing man, animals, and microorganisms. Prerequisite: Micrb. 410.

520. Histopathology (3) Specific microscopic alterations and reactions developing in the living animal body when exposed to injurious agents or deprivations.

525. Mechanisms of Hypersensitivity and Immunopathology (3) Concepts of hypersensitivity and special consideration of immunopathological conditions. Prerequisites: Biol. 437, Micrb. 410, and 3 credits of pathology.

528. Diagnostic Pathology (3-9) Gross examination of animals and birds, their tissues and body fluids for pathologic changes. Prerequisites: 6 credits in pathology, microbiology, or infectious diseases.

581. Seminar in Veterinary Science (1-4) Presentation and critical discussion of results of personal research or topics of current interest.

582. Special Problems (1-9) Investigation of special disease problems, including laboratory and field studies.

COLLEGE OF MEDICINE

GEORGE T. HARRELL, JR., *Dean of the College*
Director, The Milton S. Hershey Medical Center
Hershey, Pennsylvania 17033

Graduate Faculty, Senior Members: Professors Davidson, Morgan, Munger, and Pattishall; Associate Professors Baird, Ha, Hass, Mortimore, and Rosenberg; Assistant Professors Davis and B. Pubols.

Graduate Faculty, Associate Members: Assistant Professors Egeland, Houts, Jefferson, Lang, Miljkovic, Neely, and Thompson; L. Pubols.

Graduate Faculty Lecturer: Assistant Professor Benjamin.

ANATOMY

501. GROSS HUMAN ANATOMY (4) Macroscopic organization of the extremities and head and neck with emphasis on anatomical individuality, functional significance, and clinical correlations.

502. GROSS HUMAN ANATOMY (2) A basic study of the macroscopic organization of the human being. The course will consist of lectures, laboratory dissections, and appropriate demonstrations; anatomical individuality, functional significance, and clinical correlations will be stressed. Required of all first-year medical students and graduate students in anatomy. Other students may be admitted with permission of staff.

505. MICROSCOPIC ANATOMY (3) Microscopic organization of tissues and cells; interrelationships of cells; chemical and functional specializations of cells.

510. NEUROBIOLOGY (3) Morphology and function of the sense organs, general organization of the brain, and physiological studies of central nervous system function.

512. HUMAN EMBRYOLOGY (2) Detailed study of normal development and physiology of the embryo and fetus; attention to developmental anomalies and fertilization problems.

530. DISSECTION (2-4) Individual dissection of a particular region of the body, study of the pertinent literature, and preparation of a report.

535. SUBMICROSCOPIC ANATOMY (3) Current literature on molecular and micellar organization of cells and tissues in diverse systems; application of interference and electron microscopy.

540. SEMINAR (1 per term) Student and staff presentations designed to evaluate current research developments in anatomy.

545. COMPARATIVE VERTEBRATE OTOLOGY (3) Evolution and principles of the auditory system demonstrated by comparison of structures in ears of vertebrates; independent study expected.

570. SPECIAL TOPICS (1-6) Introduction of students to the research laboratory and scholarly pursuits of members of the staff; credit arranged by consultation.

590. RESEARCH PROBLEMS (1-12) Individualized research conducted by students in departmental laboratories. The program and credits to be arranged by consultation.

BEHAVIORAL SCIENCE

501. Behavioral Science (4) Integration of bio-psycho-social substrates of behavior, variability in behavior during development, and behavioral correlates with disease and health.

502. Behavioral Science (3) Continued integration of bio-psycho-social substrates with emphasis on adaptation, during development, and behavioral correlates with disease and health.

511. Medical Statistics and Research Design (2) Use of theoretical and applied statistics in medical research design and in the interpretation of data.

521. Primate Behavior (3) Monkey to man survey of intelligence, learning, social behavior, emotions growth, and physiology; techniques of primate research.

531. Behavioral and Physiological Correlates of Stress (3) Effects of stress on all physiological processes and role of learning, cognition, personality, and culture in adapting to stress.

535. Nervous Systems and Behavior (3) Synthesis on behavioral science, neurobiology, and physiology with emphasis on integrative functions of peripheral, central, and autonomic nervous systems.

540. Seminar (1-6) Critical discussion of current literature and research within the behavioral sciences, emphasizing research design, methods, interpretation, and synthesis.

551. Health, Illness, and Culture (3) A medical sociology seminar devoted to the socio-cultural aspects of health and sickness.

570. Special Topics (1-6) Original and current literature and research methods in special areas in the behavioral sciences.

590. Research Problems (3-12) Independent work to develop and test creative and original hypotheses.

BIOLOGICAL CHEMISTRY

502. Biological Chemistry (5) Principles of biological chemistry with emphasis on the relationship of macromolecular structure to function in metabolic pathways and specialized tissues.

503. Biological Chemistry of Nucleic Acids (2) Detailed discussion of nucleic acid biochemistry and its relation to genetic phenomena, especially organization, mutation, and segregation of genetic material.

513. Biological Chemistry Macromolecules (3) Methods of detailed determination of the three-dimensional structure of macromolecules, primarily enzymes and amino acid sequence and conformation of protein.

523. Metabolism (3) Molecular mechanisms employed by living systems to transform biological compounds, control production and utilization of energy, and regulate metabolic pathways.

540. Seminar (1 per term) Critical discussion of current literature within a facet of biochemistry; experimental design, procedures, and interpretation of results to be emphasized.

570. Special Topics (2) Discrete areas of contemporary research in conformational analysis and natural product structure, complex polysaccharide structure, neurochemistry, and biochemistry of disease.

590. Research Problems (1-12) Individualized research on biochemical problems conducted by students in departmental laboratories.

FAMILY AND COMMUNITY MEDICINE

501. Family and Community Medicine (1) An intimate view of continuing comprehensive medical care of each person in a family in the community setting.

510. Normal Sexual Development (1) The basis, development, and pattern of normal sexual development, with an emphasis on the range of "normal."

515. Economics of Health Care (1) Health costs and various means of meeting them.

HUMANITIES

501. Human Values in Medical Care (2) Analysis of questions, concepts, and ramifications of moral and religious values of health and illness; principles of professional responsibility.

505. Ethics and Human Experimentation (2) An analysis of the ethical, moral, and legal aspects of clinical investigation in medicine.

LABORATORY ANIMAL MEDICINE

501. Biology and Care of Laboratory Animals (2) Presentation of the anatomic and physiologic characteristics of the commonly used laboratory animal species and their relation to biomedical research.

503. Laboratory Animal Genetics (2) Genetic principles applied to laboratory animals used for investigations of diseases that may be controlled or influenced by genetic factors.

505. Laboratory Animal Zoonoses (2) Experimentally induced, spontaneous, and infectious diseases transmissible between man and animals with special emphasis on etiology, differential diagnosis, and control.

507. Techniques of Laboratory Animal Experimentation (2) Techniques of drug administration, infusion, and collection of body fluids and materials; gnotobiology; use of radioisotopes and bioinstrumentation.

510. Animal Physiological Surgery (2) Selected operative procedures, demonstrating principles of physiology with modern biomedical instrumentation, will be followed through the postoperative period.

515. Experimental Surgery of Laboratory Animals (3) Surgical techniques, including nephrectomy and Goldblatt clamp, bladder and gastric pouches, bile duct connulation, intraventricular operation, cardiac and cerebrovascular catherization.

530. Disease of Laboratory Animals, I (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of rodents, with emphasis on diagnostic and control methods.

531. Diseases of Laboratory Animals, II (3) Physiological and pathological expressions of both infectious and metabolic-degenerative disease of nonhuman primates and other species of animals.

535. Comparative Pathology of Laboratory Animals (3) Comparative pathologic characteristics of infectious and metabolic disease of animals and man.

540. Seminar (1 per term) Student and faculty discussions of organization and presentation of data on recent advances in selected topics of laboratory animal medicine.

570. Special Topics (1-6) Specialized training in advanced research techniques and current status of research in the various areas of laboratory animal medicine.

590. Research Problems (1-12) Research training will be given to enable the student to advance his knowledge about some aspect of laboratory animal medicine.

PHYSIOLOGY

520. Medical Physiology (2) Cellular physiology including membrane permeability, bioelectric potentials, muscle contractions, secretion; cardiovascular physiology including hemodynamics, cardiac function and output, peripheral circulations.

521. Medical Physiology (4) Organ and metabolic physiology, including renal, endocrine, neuromuscular, gastrointestinal, and respiratory.

525. General Physiology (2) Cellular processes of accumulation membrane transport, bioelectric potentials, contraction, and secretion in erythrocytes, nerves, sensory receptors, muscles, glands, excretory organs.

530. Metabolic and Endocrine Physiology (3) Regulation of carbohydrates, fatty acid and protein metabolism; regulation of hormone secretion; effects of hormones on water and cell metabolism.

550. Seminar (1 per term) Critical appraisal by staff and students of current research developments and of data collected in current investigations.

570. Special Topics (1-6) Training in the use of research techniques; examination in depth of a specialized topic on the level of current research.

590. Research Problems (1-12) Individualized research conducted by students in departmental laboratories.

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